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Introduced Earthworms of South Africa. On their taxonomy, distribution, history of introduction and on the extermination of endemic earthworms

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With 12 figures

Abstract

Of about 170 earthworm species known from South Africa 23 (or 24) species representing six (or seven) families have been introduced. Great genital polymorphism was found in *Allolobophora trapezoides* and *Eisenia rosea*. All morphs of the latter have developed after its introduction to South Africa. *Pheretimas* might have been introduced by Indonesians in A. D. 400–500, while most species were introduced by Europeans after 1505; introduction by Africans (800–900), Indians, Arabs (800–1200) and Chinese (1200–1500) is also possible. The distribution corresponds to the geographical origin of the species and climate, temperate species occurring in the interior, tropical species along the E coast and the NE Transvaal. Endemic earthworms have been, and are, exterminated by man's changes of the environment, acanthodrilines by the removal of indigenous forests, microchaetoids by lowering of the ground-water table and desertification of the savannas. No evidence for competition between endemic and introduced species was found. The peregrine earthworms are often characterized by reproducing parthenogenetically, a great morphological (and genetical) variability and physiological adaptation to dry, poor soils, while these characters are usually absent in endemic species.

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1. Introduction

South Africa has an area of 1223000 km², corresponding to 26% of that of Europe, extending from 34° 51′ S to 22° 15′ S. Topographically, it consists of the interior plateau with elevation from 500—1800 m falling gently to sea level in the south and west while in the east it ends abruptly at the Drakensbergen escarpment. The Drakensberg Mountains rise to well over 2000 m in the Lesotho highlands.

Precipitation and temperature show a W-E gradient, rising from less than 10 mm/yr in Namibia to over 2000 mm in the Northeastern Transvaal and on the

eastern slopes of the Drakensberg Mountains while temperatures range from temperate to subtropical. The vegetation is very xeric in most parts of South Africa, Karroo and scrub occupying the Cape, the Orange Free State and the Transvaal while grassland and patches of forest are present in the eastern Cape, Natal and north-eastern Transvaal.

Only the eastern slopes of the Drakensberg Mountains are well drained by many streams, while on the western side of the escarpment only a few small rivers (the biggest being the Orange) are present, often only during the rain-period and immediately thereafter; lakes of any consequences are absent.

The colonisation of South Africa by Europeans changed its scenery fundamentally. Already in the late 19th century big game was so scarce that hunters began to shun South Africa for the richer East African plains. At the turn of the century the Krueger National Park was established as an attempt to preserve the remnants of the big game that was left. Soil erosion and destruction of vegetation was, however, allowed to continue at an ever-increasing speed, the interior of the Cape is now only fit for sheep and goats, dust-storms in the Free State are frequent and can occassionally "turn day into night" as one observer described it.

Being a highly developed industrial nation South Africa has more than its fair share of water, soil and atmospheric pollutions. To summarize, South Africa is now in the same state as the big Badlands of the U.S.A. or the La Plata countries.

The effect on the soil fauna has been tremendous, as a matter of fact this investigation started because introduced forms were the only species procurably on the plateau. Scores of localities were examined around Potchefstroom and in the northern Free State without yielding a single earthworm. The earthworm fauna of the central Transvaal is a poorer image of the Swedish one. Reconstruction of the western limit for endemic earthworms is no longer possible. Many species must have been, and certainly are, exterminated. A case is provided by the giant microchaetoids which, due to their castings making farming impossible, are destroyed with the help of bull-dozers.

Twenty-three species are treated as indroduced in this paper while one more species, *Nemertodrilus kellneri* MICHAELSEN 1910, is probably also introduced but it has been considered unwise to include it till its type-locality has been visited. Altogether about 170 species are known for South Africa, three for Lesotho, two for Ngwane, nil for Botswana and 13 for Namibia (MICHAELSEN 1914).

Taxonomic nomenclature is defined in LJUNGSTRÖM (in press), meterological regions on p. 67 Other abbreviations are: AJR = A. J. REINECKE; BM(NH) = British Museum (Natural History), London; DM = Durban Museum, Durban; distr. = district; IM = Indian Museum, Calcutta; PM = Museum Nationalle d'Histoire Naturelle, Paris; POL = P.-O. LJUNGSTRÖM; rd = road; RM = evertebratavdelningen, Naturhistorika Riksmuseet, Stockholm; TM = Transvaal Museum Pretoria; ZMH = Zoologisches Museum, Hamburg. In the locality lists C, N, O, T refers to the four provinces Cape, Natal, Orange Free State and Transvaal respectively. Figures in brackets

refer to number of specimens. (N 1, 2) is read "two specimens from locality N 1". South Africa, Zimbabwe, Namibia, Lesotho, Botswana and Ngwane refers to the Republic of South Africa, the colonies of southern Rhodesia and South West Africa, the former colonies of Basutoland, Bechuanaland and Swaziland respectively.

By peregrine is meant any species that occurs on at least two continents, usually several; by oligoporeutic (WILCKE 1955) a species that has a much wider distribution than is normal for the group but is restricted to one continent, e.g. *Iritogenia grisea*.

This paper is based on over 1400 specimens from over 130 localities, of which 128 South African localities were visited personally during the present investigation. Number of specimens and localities listed under each species refers only to those situated in South Africa that were collected during the present investigation.

Most of the material has been deposited in the Zoological Institute, Potchefstroom University, Potchefstroom, South Africa, a few specimens have been placed in RM.

I am indebted to Mr. A. J. REINECKE (Potchefstroom) for much valuable help and for material, also to Dr. T. KARLING (Stockholm) for making space available in RM, to Messrs. Å. ANDERSSON, R. BÄCKSTRÖM and R. OLERÖD (Stockholm) for technical and other assistance, J. MATTHEW and P. MULDER (Potchefstroom) for material and last but not least Dr. G. E. GATES (Bangor, Maine) for valuable information on several taxonomical problems.

2. Taxonomical section

2.1. Acanthodrilidae

In agreement with SIMS (1966 and 1967) this family is divided into two subfamilies, Acanthodrilinae and Octochaetinae instead of giving each family status as was done by GATES (1959).

2.1.1. Acanthodrilinae

Endemics of this subfamily are present in all the Gondwana continents. There are five genera present in South Africa, viz. *Chilota*, *Eodrilus*, *Microscolex*, *Pontodrilus* and *Udeina* with 94 species of which 91 are endemic. *Pontodrilus bermudensis* BEDDARD, 1891 is a littoral species occurring along the shores of all continents in the tropics and subtropics. It has probably not reached this distribution by the agency of man. It was recorded from the coast of Natal by MICHAELSEN (1913c).

The genus *Microscolex* is represented in South Africa by three species of which two are peregrine. The third, *M. lusiae* MICHAELSEN, 1899 might be endemic but so little collecting has been done in other areas in which the genus occur that it cannot be excluded that this species is introduced. All other endemic species of *Microscolex* occur in southern South America, the subantarctic Islands, New Zealand and possibly Panama.

The South African endemics usually have a very restricted distribution, one species is only known from about four square metres but there are a few species which have reached a very wide distribution within South Africa through, at least in part, the agency of man.

2.1.1.1. *Microscolex dubius* (FLET.) 1887

(1 specimen from 1 locality)

Microscolex dubius, MICHAELSEN 1899a: 97; 1908: 35; 1910: 66; 1913c: 495; 1933: 429; PICKFORD 1937: 429—432, f. 398—399.

Previous records: Cape Province, Port Elizabeth (MICHAELSEN 1899a); Cape Flats, Farm Bergvliet (MICHAELSEN 1908); French Hoek and Cape Town (MICHAELSEN 1913c); Uitenhage (MICHAELSEN 1933); Sea Point near Cape Town and Cape Peninsula, etwa $^1/_2$ mile from Hout Bay on the Chapman's Peak Road (PICKFORD 1937).

Orange Free State, Boshof (MICHAELSEN 1910).

New records: C4, Craddock distr., Craddock. June 1967. v. d. WALT. 0-0-1.

External: Length 76 mm. Width 5 mm. Colour greyish. Number of segments 116. Prostomium epilobous 1/3, tongue open. Setae closely paired, ratio on x: AA = 35. AB = 15, BC = 23, CD = 20, DD = 55 or 1/4 C; on 1: AA = 28, AB = 20, BC = 35, CD = 21, DD = 55 or about 1/5 C. Dorsal pores absent.

Clitellum annular on xiii—xvii, very thick, about 0.75 mm. Spermathecal pores absent. Female pores in invaginations, presetal on xiv in A. Prostatic and male pores open through a common duct on small, disc-shaped porophores in AB of xvii. Genital markings absent.

Internal: Pigment absent from either muscle layer. Septa 7/8—13/14 equally thickened. Salivary glands extending over vi. Gizzard vestigial. Calciferous glands absent. Hearts in vii-xii. Nephridial vesicle J-shaped.

Testes and funnels free in x, xi. Seminal vesicles in xi, xii. Prostates confined to xvii. Spermathecae absent.

Reproduction: The male funnels were iridescent but since spermathecae were absent this worm was parthenogenetic.

Parasites: White gregarinid cysts was found attached to the preclitellar septa.

Distribution: All but one record are from the south coast, in M, A and Sn regions. First find in about 1898. Original home probably Patagonia or Subantarctic Islands.

2.1.1.2. *Microscolex phosphoreus* (DUG.) 1837

Microscolex phosphoreus MICHAELSEN 1899a: 97, 1899b: 434; 1908: 35; PICKFORD 1937: 433—436, f. 400—404; SCIACCHITANO 1960: 10.

Previous records: Cape Province, Port Elizabeth (MICHAELSEN 1899a); "Kafferlandet" (MICHAELSEN 1899b); Little Namaland, Kamaggas (MICHAELSEN 1908); Mossel Bay (PICKFORD 1937); Cape Peninsula, Hout Bay, Skoorstenkop (SCIACCHITANO 1960).

Natal, Krantzkop (Pickford 1937).

Transvaal, Zoutpansbergen, small kloof NW of Louis Trichard (PICKFORD 1937).

Lesotho, Makhek Mts., 10 miles ENE Mokhotlong (SCIACCHITANO 1960).

New records:

Natal, Pietermaritzburg. Leg. D. WARREN. Det. W. MICHAELSEN 1929 (ZMH).

Distribution: It has been found dispersed all over eastern South Africa from Cape Town to near the Rhodesian border. Contrary to all other South African acanthodrilines it has more often been found inland than along the coast. In M, A, Sn and H regions. First collected in about 1850—1860. Original home probably Patagonia or the Subantarctic Islands.

2.1.2. Octochaetinae

Endemic species and genera occur in New Zealand, India, tropical and southern subtropical Africa, northern South America, Central America including the West Indies and southern U.S.A.

Peregrine species are found in *Dichogaster* of which two are present in South Africa.

No endemic species have been found in South Africa but they are present in Zimbabwe, Malawi and Mozambique which is the southern limit of the genus. No collecting have so far been done in the extreme northeastern Transvaal and adjacent parts of Mozambique so the presence of endemics in that region cannot be excluded.

2.1.2.1. *Dichogaster bolaui* (MICH.) 1891

(1 specimen from 1 locality)

Dichogaster bolaui, MICHAELSEN 1913e: 417—418.

Previous records: Natal, Pietermaritzburg, Scottsville (MICHAELSEN 1913e).

New records:

T30, Middelburg distr., Blinkpan coal mine. March 1968. M. APPELBRYN. 0-0-1.

External: Number of segments 124. Prostomium epilobic. Setae closely paired and ventral. First dorsal pore in 5/6.

Clitellum saddle-shaped, reaching $^1/_2$ BC, anterior border very indistinct, on xiv—xx. Prostatic pores close to mV and not situated on papillae, two pairs on xvii, xix. Male pores one pair near mV on xviii. Spermathecal and female pores not seen. Genital markings absent.

Internal: Gizzards, two, apparently in vii, viii. Septum 7/8 absent. Calciferous glands crescent-shaped, apparently in xv, xvi and xvii. Intestinal origin apparently in xviii. Three rows of meronephridia on each side. Spermathecae one pair in vii.

Distribution: First collected in 1911 in a garden in the D region, the second find is in the Sn region. Original home probably somewhere in West Africa.

2.1.2.2. *Dichogaster saliens* (BEDDARD) 1893

Dichogaster crawi, MICHAELSEN 1913e: 418—419.

Previous records: Natal, Pietermaritzburg, Scottsville and Chapel street.

Distribution: From gardens in the D region. First collected in 1911. Original home probably West Africa.

2.2. Glossoscolecidae

This family is endemic in South America south to pampas and north to Nicaragua and possibly the Antilles; South Africa and Madagascar.

There are three endemic genera with about fifty species, including several to be described in another paper, in South Africa.

The family can boast only one peregrine species, *Pontoscolex corethrurus* (Fr. Müller) 1857 which is distributed in most parts of the tropics and subtropics. Except for the Uganda record it has only been found near the coast in those areas where it has been introduced, but this is probably due to collecting activity rather than to biographical reasons.

2.2.1. *Pontoscolex corethrurus* (Fr. Müller) 1857 (Fig. 1 + 2, Table 1) (345 specimens from 18 localities)

Pontoscolex corethrurus, Michaelsen 1913e: 422

Previous records: Natal, Pietermaritzburg, Chapel street and Umgeni near Durban in a plantation (Michaelsen 1913e).

N 3, Zululand, Inyezane River, near bridge on the Gingingdlovu-Empangeni-rd. 8. v. 67. POL. 0-0-1

N 7, Lower Tugela distr., small stream at entrance to Stanger from Durban rd. Grass-field, covered with reeds of sugar cane. Very heavy, black, sandy soil. 9. v. 67. POL. 0-0-2

N 9, Lower Tugela distr., Etete River at the old Stanger-Tongaat-rd. Grassfield. Very wet, sandy soil. 9. v. 67. POL. 2-0-9

N 10, Lower Tugela distr., dam at Tongaat. Eucalyptus. 0—5 cm black, sandy, soil, deeper down sand. 9. v. 67. POL. 1-1-1

N 11, Lower Tugela distr., Mdloti River on the Tongaat-Verulam-rd. Grassfield, near a swamp. Worms found on the elevated parts. Very heavy and rather dry soil. 0—2 cm sand, 3-bluish-black clay. 9. v. 67. POL. 0-0-27

N 12, Inanda distr., about 3 miles from Mt. Edgecombe on the Umgeni rd. Sugar cane field. Worms found a few feet off the edge of the field. 10. v. 67. POL. 1-0-3

N 14, Umlaxi distr., Amanzimtoti Mission Reserve (near Adam's mission), Tiller station. Extremely sandy soil. Worms found on a slope. Wild grass. 10. v. 67. POL. 2-0-2

N 15, Umlazi distr., Amanzimototi Mission Reserve. Adam's mission. In an arable field. Grassfield. rich, blackish soil. 10. v. 67. POL. 0-0-3

N 20, Umzinto distr., at a dam at coast road 25 miles N of Port Shepstone. Grassfield, black, clayey soil on sand. 12. v. 67. POL. 2-0-2

N 21, Umzinto distr., 1 mile from Park Rynie on the Park Rynie-Umzinto-rd. Grassfield, black, sandy soil. Worms down to 15 cm. 12. v. 67. POL. 1-0-3

N 22, Umzinto distr., 1.5 miles from Park Rynie on the Umzinto-rd. Grassfield, black, sandy soil. Worms down to 15 cm. 12. v. 67. POL. 5-0-15

N 24, Umzinto distr., Glenrosa station (Lot 23), dam SW of main-rd, app. 7 miles from Umzinto on the Ixopo-rd. Grassfield, black, wet soil. 12. v. 67. POL. 0-0-1

N 27. Umlazi distr., Umgababa dam. On a slope covered with grass. Sandy (fine to coarse), sometimes black rich soil (0—5 cm) on rock. Two worms found under stones. 13. v. 67. POL. 2-0-6

N 31. Ixopo distr., 1/4 mile from Umzimkulu on the Ixopo-rd, Hancock Grange 2017. Grassfield, dark brown, rather wet soil. Worms found 0.5 cm. 15. v. 67. POL. 0-0-1

N 41. At Scottsburgh on the Port Shepstone-rd. 17. x. 67. AJR & POL. 1 tail-piece.

T 16. Krueger National Park, Skukuza village. On the bank of Sabie River. Among roots of reeds and grass. 10. ix. 67. J. MATTHEW. 28-0-216

T 19. Tzaneen distr., on the Zzaneen-Strydom tunnel rd., appr. 20 miles from Tzaneen. At small stream. 9. vii. 67. AJR 0-0-1

T 36. Nelspruit, at the river bank. ?. iv. 67. AJR 1-0-5

Malawi

Zomba, small stream at N end of town. 1. vii. 68. POL. 2-0-5 + 2 tail-pieces. Beginning of July 68. 10-1-9

Uganda

Jinja, in a wet ditch flowing through swampy meadow on the shore of Lake Victoria, appr. 50 m from the water's edge. 10. vii. 68. POL. 1-0-0

External: Length 48—70 mm. Width 2—4 mm. usually 2—3 mm. Unpigmented greyish with a yellow zone on posterior quarter of the body (see below). Number of segments (Fig. 1) 130—232 (222), if only the T 16 population of 161 specimens are considered 135—232. Mean of (222), 177.427, mean of T 16 sample (161) 181.739. 90 % of the worms had 152—202 segments. i and ii with many longitudinal grooves. Segments biannulated from x or xi to clitellum. Prostomium contracted and not visible (all).

Setae apparently present on first and last segment due to contraction of the real first and last segments. Ordinary setae (Fig. 2) smooth, rather thick (especially on hindbody), sigmoid and with a node. The node is more apparent on preclitellar setae than those on the hindbody. Setae associated with genital papillae ("genital" setae) of the same shape and size as ordinary setae. Nephropores exactly in C visible only from 9/10 or 10/11 backwards.

Clitellum saddle-shaped, reaching to B and with intersegmental furrows clearly visibly, over xv, xvi—xxi, xxii or xxiii covering 7—9 segments, mean 7.81 (61). The

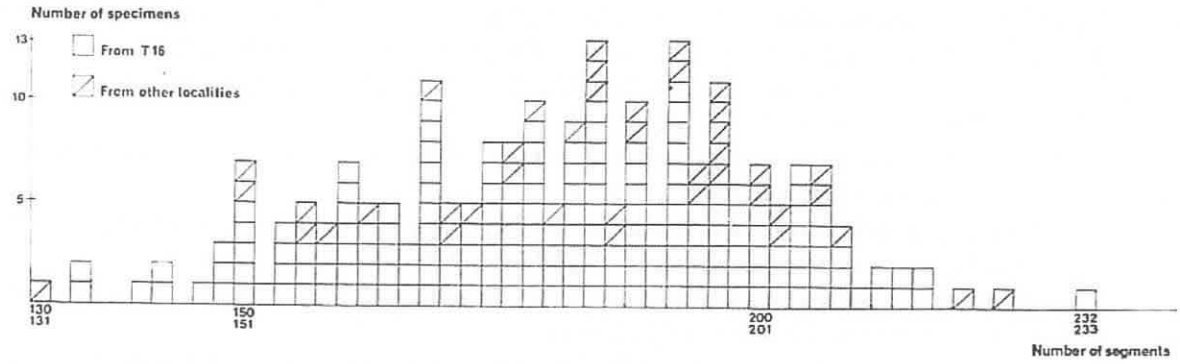

Fig. 1. Number of segments in 222 specimens of *Pontoscolex corethrurus*.

position of the clitellum varied as follow: 15—21 7 (7 specimens), 15—½22 7.5 (1), ½15—22 7.5 (22), 15—22 8 (8), ½15—½23 8 (24), 15—23 9 (2), 16—22 7 (1).

Tubercula pubertatis as narrow, slightly elevated, smooth bands, tapering at either end, sometimes with ventral intersegmental incisions, between BC on xviii, xix—xx, xxi, xxii, covering three of four segments, mean 3.33 (48). The position and extent of the tubercula pubertatis varied as follow: 18—20 3 (5 specimens), 18—½21 3.5 (2), 18—21 4 (5), 19—21 3 (24), ½19—½22 3.5 (10), 19—22 4 (2).

Spermathecal and male pores not seen. Female pores only seen in one specimen where a single pore-like marking was found on one side in 14/15 in A. All specimens innornate except those from T 16 and Malawi where a pair of papillae were found associated with a b of xvi or xviii in many specimens although an exact count was not kept and from N 14 where one specimen had transversal, glandular bands between BB on xv, xvi and xvii.

Internal: Septa 5/6—7/8 and 9/10 thickened and strongly conical, 8/9 lacking. Septa displaced backwards about one segment. Gizzard in vi covered by 5/6 (4). Calciferous glands in vii, viii and ix united with oesophagus by a mesial, thin duct. Anterior face of the glands looks reticulated due to the blood-vessels. Apparently there are

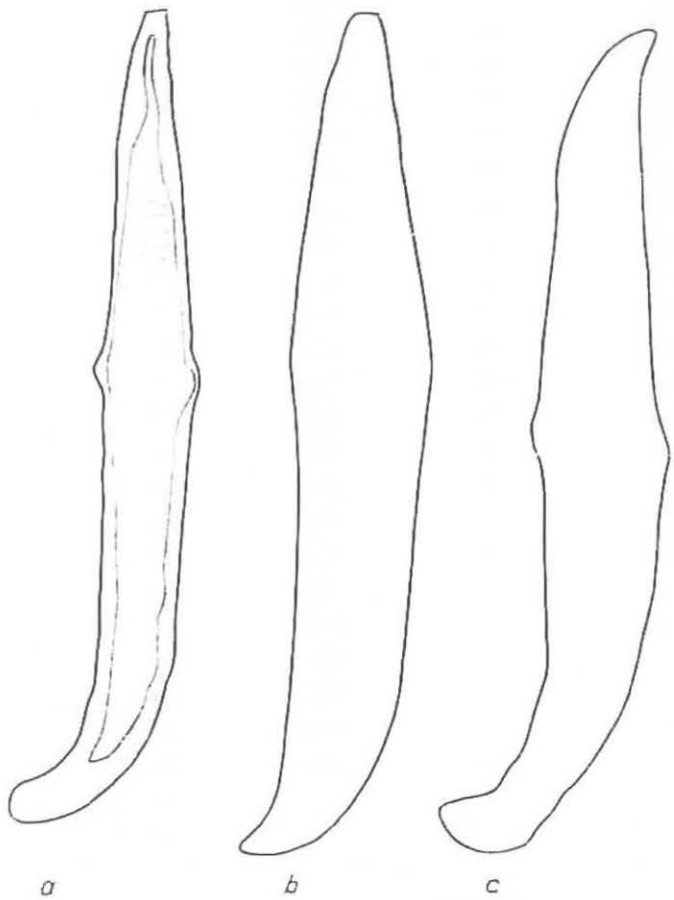

Fig. 2. Setae of *Pontoscolex corethrurus*. a + b) setae from hind-body, c) ventral anteclitellar seta.

three main vessels running transversally over the gland and from which many smaller ones are branching off. Intestinal origin probably in xv or xvi.

Nephridia, clusters anterior to 5/6 with ducts running to the parietes, and entering it at C. Testis sacs absent. Ovaries in xiii with a big long egg-string. Seminal

Table 1 "Growth zone" in *Pontoscolex corethrurus*

	"Growth zone" extension	"Growth zone" Number of segments	Number of segments	Number of segments behind „growth zone"	Remarks
	102—106	5	185	79	
	114—125	12	201	76	
	115—121	7	178	57	
	116—123	8	157	34	
	118—126	9	196	70	
	119—129	11	189	60	
	120—124	5	187	63	
	120—125	6	184	59	
	122—127	6	173	46	
	122—127	6	208	81	Amputee
	122—128	7	192	64	
	122—129	8	176	47	
	122—129	8	225	96	
	123—127	5	158	31	
	123—128	6	186	58	
	123—130	8	197	67	
	123—130	8	220	90	
	124—128	5	196	68	
	124—129	6	194	57	
	124—129	6	194	57	
	125—128	4	196	68	
	125—131	7	183	52	
	125—132	8	192	60	
	126—129	4	150	19	Juvenile
	126—132	7	170	38	
	126—134	9	169	35	
	127—131	5	177	96	
	127—132	6	163	31	Amputee
	128—133	6	157	24	
	128—135	8	170	35	
Range:		4—12		19—96	
Mean:	ca. 120—ca. 130	6.87		73.45	
		ca. 10			T 16

vesicles absent in worms from all localities in South Africa and Malawi. Spermathecae present in worms from all localities in Malawi and South Africa. Spermathecae long, narrow, somewhat club-shaped in vii, viii and ix. Tubercula pubertatis glands tripartite, big in xviii, then diminishing in size backwards, The three glands are clearly separated from each other by intersegmental grooves at 18/19 and 19/20.
Growth: A "growth zone" (Table 1) of very narrow, yellow segments were found near the posterior end of the worms, usually situated on cxx—cxxx but can begin as far forward as cii covering between 4 and 12 segments, mean (30) 6.87 segments. In 90% of the worms it covered 5—8 segments. There are 19—96 segments behind the "growth zone" the lowest figure represented by a juvenile, if this one is excluded the figures are 24—96, mean 73.45 segments.

That this yellow zone really is a growth zone can only be settled after further research. Although no embryos have been available one can suspect from the wide variation in number of segments in adults that segment formation is continuous throughout life in *P. corethrurus*.
Reproduction: The spermathecae have always been empty, seminal vesicles always lacking. This species must thus be parthenogenetic. It is interesting to note that VANUCCI (1953) never was able to observe copulation in her cultures specially kept for this purpose, although cocoon-production was frequent.

Gut content: Soil, sometimes with pebbles and big pieces of vegetable material.
Ecology: This species is, together with the Pheretimas, the most abundant earthworm in sugar cane fields. It is a surface-living species occurring in the upper five cm of the soil and only rarely found as deep as 15 cm. It has been found in sand to clayey soil. It has only once, during the present investigation, been found in diapause although it has been collected in very dry soil (so dry that oll other earthworms species had died out).
Distribution: *P. corethrurus* have been recorded from E, L and Nt regions. First collected in 1911. Original home is to be looked for in or around the Guayanas.
Remarks: Although one of the commonest earthworms in the tropics and subtropics its gross anatomy is still imperfectly known. BAHL (1942) has described the nephridia but his conclusions have been disputed by GATES (1943). STEPHENSON (1923) records the absence of septum 9/10 but GATES (1943) says that all septa are present. In this paper a third view is presented, viz. that 8/9 is lacking and that 9/10 is thickened (thin according to GATES). GATES (l. c.) records the intestinal origin as "probably in xiv or xv" here as probably in xv or xvi. These contradictory statements are mainly due to the difficulty in ascertaining the segmental location of organs. The prostomium and i is always retracted and sometimes also ii. Likewise one to several of the last segments are retracted in a telescope fashion so the number of segments recorded are usually too low. The backward displacement of septa also makes the interpretation of the location of internal organs difficult or impossibly.

This species protrude its prostomium for about five mm, investigating the surrounding soil, then retracting it. The movements are very rapid and are reminiscent of the movement of the tongue in snakes. The prostomium is well supplied with nerves and this species probably obtains information on soil moisture and chemistry in this way.

2.3. Lumbricidae

The latest revision is that of OMODEO (1956a). According to him there are nine genera and 171—183 species. Although several species have been described since then, the total will probably not be more than about 150 when the synonymies are cleared out.

Peregrine species occur in *Allolobophora*, *Bimastos*, *Dendrobaena*, *Eisenia*, *Eiseniella*, *Lumbricus* and *Octolasion*.

Endemic species occur in Europe and Asia in an area limited to the north by the greatest extension of the glaciers during the last Ice Age and to the south by desert (Sahara) and the Alai-Pamir-Alatau-Tian-Shan ranges. The eastern border is not yet known but might be at the Okhotsk Sea. Endemic lumbricids are also known from the eastern United States and Hokkaido. The origin of the family have been sought in the Balkan and in the region north of the Black Sea.

The peregrine species have penetrated most of the subarctic, subantarctic and temperate regions and have occasionally been found in the subtropics.

Because of the widespread polymorphism, parallel evolution and, at least an apparent, monotony in their somatic anatomy the lumbricids are in a taxonomic chaos unequalled among the Oligochaeta.

2.3.1. *Allolobophora caliginosa* (SAV.) 1826

Allobophora caliginosa MICHAELSEN 1899a: 97
Helodrilus (*Allolobophora*) *caliginosus*, MICHAELSEN 1908: 41
Helodrilus (*Allolobophora*) *caliginosus* f. *typica*, MICHAELSEN 1913b: 61, 1913c: 551—552
Allolobophora caliginosa, PICKFORD 1937: 37

Previous records: Cape Province, Port Elizabeth (MICHAELSEN 1899a); Little Namaqualand, Kamaggas (MICHAELSEN 1908); Stellenbosch (MICHAELSEN 1913c); Paradise Estate near Kirstenbosch and Cape Flats (PICKFORD 1937).
Transvaal, Johannesburg, in a garden (MICHAELSEN 1913b); Kruegersdorp district, Witpoortje Falls (PICKFORD 1937).

Distribution: From M, W and Sn regions. First collected about 1898. Original home Europe or adjacent parts of Asia.

Remarks: None of these specimens have been available for examination. Since no *caliginosa* was found during the present investigation it cannot be excluded that the above records are referable to *trapezoides*. This seems at least to be the case with the Port Elizabeth record. GATES (1958a) states that *A. turgida* is present in South Africa.

2.3.2. *Allolobophora trapezoides* (Dug.) 1828 (Table 2—6)
(33 specimens from 11 localities)

Lumbricus capensis Kinberg 1866: 100 (Types, a single specimen in RM (Type coll.) No. 1938; type locality "montes juxta urbem Cap" (= Table Mountain).
Lumbricus capensis, *Allolobophora* (sp.). Michaelsen 1899b: 423—424 (reexamination of type)
Helodrilus (*Allolobophora*) *caliginosus* f. *trapezoides*, Michaelsen 1913b: 61. 1913c: 552, 1913e: 448
Allolobophora caliginosa f. *trapezoides*, Černosvitov 1941: 226
Allolobophora caliginosa trapezoides, Jamieson 1967: 77—84
Allolobophora trapezoides, Reinecke & Ljungström 1969: 106—111 f. 4: A—C, 5: A—D, Table 7—8
Allolobophora longa (non Ude), Reinecke & Ryke 1969: 521—523
Previous records: Cape Province, Knysna (Michaelsen 1913c); Table Mt. (Kinberg 1866); Krom River, just north of Stellenbosch (Jamieson 1967).
Natal, Howick, at foot of the Umgeni Falls (Michaelsen 1913e). Transvaal, Johannesburg, in a garden (Michaelsen 1913b); Potchefstroom (Reinecke & Ljungström 1969).
New records: Cape Province, Cape Town, 28. viii. 1872. G. D. Vylder, det. E. Perrier. 0-0-3 (RM, No. 86); (? Cape Town), The Lion's rump. 1872. G. D. Vylder, det. W. Michaelsen. 0-0-4 + one tail-piece (RM, No. 42). C 1, Uitenhage, Kerkstraat. In a garden. 15. iv. 67. Mrs. L. Matthews. 2-9-9-1
C 2, Groot Brak Rivier Staasie. 17. ii. 67. B. J. J. Haasbroek. 0-4-2-2
C 3, Heidelberg. In a garden. Limey, wet soil. P. de Kock. 22. ii. 67. 3-0-13
C 7, About 1 mile from Kokstad on the Matatiele rd. near a high school. At outlet of polluted water. Soil black 0—3 cm then brownish. Grass field. 18. x. 67. POL & AJR. 0-0-1
N 40, Howick, at foot of the Umgeni Falls. Grass. Some trees and bushes. 16. x. 67. AJR & POL. 1-3-2
T 1, Roodeport. In a garden. Brown soil and manure. 4. xii. 67. AJR. 0-0-8
T 2, Potchefstroom, at flooded area of Mooi River, Willow trees. 13. ii. 67. POL & AJR. 0-0-6
T 11, Potgietersrus district, Rondedoom Farm. 11. vii. 67. AJR. 0-6-3
T 12, Pietersburg. Boomstreet 99. In a garden. 10. vii. 67. AJR. 0-0-38
T 23, Ermelo district, Artholo. 25. i. 1911. M. Forbes (TM). 0-0-5
T 28, Loskop dam. Trees, grass field with rich organic soil. 3. x. 67. J. Matthew. 1-0-14

External: Length 40—135 mm usually 90—100 mm. Width 3.5—5 mm. Unpigmented white to very dark brown or almost black. Number of segments in adults (19) 121 to 162, mean 139.9, in aclitellates (2) 139 overall mean (21) 139.5. Segments usually trianulated from xvii onwards, sometimes from ix onward. Prostomium and first segment with longitudinal grooves in some specimens. First dorsal pore in 4/5 (3), 5/6 (1), 6/7 (2), 7/8 (3), 8/9 (7), 9/10 (15), 10/11 (2), ??11/12 (1), 11/12 (2), 12/13 (1) and 13/14 (1).

Clitellum saddle-shaped (21) or "annular" (see note to Table 2) at least in part of its extension (57). Intersegmental furrows invisible dorsally and very faint or invisibly ventrally, on (Table 2) xxvi, xxvii, xxviii, xxix—xxxi, xxxii, xxxiii, xxxiv, xxxv covering five to ten segments. Tubercula pubertatis absent (7) or as rather

faint, narrow to broad bands, not interrupted by intersegmental furrows, on (Table 3) xxviii, xxix, xxx, xxxi—xxx, xxxi, xxxii, xxxiii, xxxiv covering 2.5 to 6 segments. Female pores round, equatorial and just lateral to B. Male pores minute, equatorial above B to 1/2 BC on ellipsoidal gland restricted to xv or extending slightly into xiv

Table 2 Position of the clitellum in *Allolobophora trapezoides*

Saddle-shaped	Annular[1])	Number of specimens
26—32	—	1
26—33	—	1
26—34	26—34	1
26—34	30—34	6
26—35	30—35	2
27—31	—	1
27—32	—	1
27—33	30—33	1
27—34	—	4
27—34	30—33	12
27—34	30—34	34
27—34	32—34	1
27—35	—	9
27—35	30—35	1
1/2 27—34	30—34	1
1/2 27—1/2 35	30—34	1
28—34	30—34	7
28—35	30—35	1
29—34	—	1

1) Ventrum on segments indicated with a very thick glandular tissue that continues to border of clitellum and obliterates intersegmental furrows. Glandular tissue on ventrum has a somewhat different appearance under the dissection microscope and might have been formed by induction from genital markings rather than by the clitellum.

Table 3 Position of the tubercula pubertatis in *Allolobophora trapezoides*

Position	Number of specimens	Position	Number of specimens
absent	7	30—1/2 34	2
28—30	4	30—34	11
28—1/2 31	5	30—35	1
28—31	1	1/2 30—1/2 34	3
1/2 28—1/2 31	2	1/2 30—34	1
29—31	1	31—1/2 33	5
30—32	3	31—33	14
30—33	4	31—1/2 34	2
		31—34	3

Table 4 Position of genital markings behind xii in *Allolobophora trapezoides*

Position of GM of ab	Number of specimens
26—30	1
26—31	1
26—32	3
26—33	1
27—30	1
27—31	1
27—32	2
28—30	3
28—32	1

and xvi, gland absent in five specimens from T 1. Genital markings behind xii absent in all worms except those from T 28 where they were present in AB on xxvi to xxxiii (Table 4).

Internal: Seminal vesicles in ix—xii, in one specimen vestigial and almost invisible. Spermathecae in 9/10 and 10/11 wholly within septa and attached to parietes at CD. Testes and ovaries in usual position. Typhlosole (Table 5) ends in xcii—cxvi leaving 21—49 posterior atyphlosolate segments.

Reproduction: Spermathecae of all worms empty. No iridescence was found on funnels of any worms except those from T 2 where funnels were very big and iridescent. *A. trapezoides* is said to be facultatively parthenogenetic. The T2 worms must then belong to a gynogenetic morph.

Regeneration: A head regeneration had produced a worm with clitellum on xix—xxvi.

Distribution: *A. trapezoides* occurs in the most varied regions, M, A, K, E, Sn and Nt. First collected in 1853. Original home Europe or adjacent parts of Asia.

Remarks: MICHAELSEN (1913c) and JAMIESON (1967) also list Port Elizabeth and Cape Town on the authority of MICHAELSEN (1899a, 1908) but in those papers he only names *A. caliginosa*. Possibly MICHAELSEN reexamined the specimens for his 1913 paper and found them to be *trapezoides*.

In Potchefstroom only very dark specimens of *trapezoides* have been found in dark brown to black soil. The unpigmented specimens were collected in light red (lateritic) soil and in soil of unknown colour. PICKFORD (1926: 224) stated that in South Africa darker and paler varieties of *Allolobophora caliginosa* occur; KOLLMANSPERGER (1934) have also reported that the colour varies according to soil type. As *trapezoides* is a top soil species there would be a certain adventage in having a colour matching the soil as protection against predators.

The type of *Lumbricus capensis* KINBERG 1866 is immature and almost transparent. Only a few observations could be made. The region of xxx—xxxiv is slightly glandular on the ventral side. Tubercula pubertatis are seen as very slightly elevated

Table 5 Ending of typhlosole in *Allolobophora trapezoides*

Number of segments	Ending of typhlosole	Atyphlosolate segments	Remarks
116	92	24	
120	99	21	
123	94	29	
123	100	23	
124	98	26	
126	105	21	
127	96	31	
127	101	26	
129	93	36	
130	101	29	
131	101	30	
131	103	28	
131	104	27	
132	100	32	
132	105	27	
133	106	27	
134	95	39	
135	94	41	
135	100	35	
135	103	32	
136	111	24	
136	93	43	
137	104	33	
137	106	31	
137	106	31	
137	107	30	
139	102	37	
140	104	36	
140	108	32	
140	108	32	
140	110	30	
141	98	43	
141	107	34	
142	111	31	Reg. 114/115
143	112	31	
145	101	44	
145	106	39	
145	106	39	
146	111	35	
148	106	42	
149	112	37	
151	110	41	
152	107	45	

(Continuation Table 5)

Number of segments	Ending of typhlosole	Atyphlosolate segments	Remarks
153	108	45	
153	123	30	
156	110	46	
162	113	49	
162	116	46	
Range:	92—123	21—49	
Mean:	104.062	33.670	

glandular areas on xxxi—xxxiii. The worm is milky white and no trace of pigment were seen in either muscle layer, neither were there any dark brown stains in the body wall which is so frequent in old specimens of pigmented worms. The only species known from the Cape with that arrangement of the clitellum and the tubercula pubertatis is *A. trapezoides*. Size and habitus of *L. capensis* is also like that of *trapezoides*.

Allolobophora caliginosa was described by SAVIGNY in 1826, two years later DUGÈS described *A. trapezoides*. Until the work of EVANS, *trapezoides* was either considered a synonym of *caliginosa* or as a forma or variety of the latter. In 1946 EVANS described some worms from England under the name *nocturna*, and in 1948 he erected *iowana* on American material. This was the beginning of the splitting of *caliginosa*. GATES (1952) followed by creating *arnoldi* and *molita*, also on American material. CAIN (1955) made a thorough study of British and continental material and concluded that there were two species, *caliginosa* and *iowana*. He accepted *nocturna* but made no reference to *arnoldi* or *molita*. He considered *iowana* to be a synonym of *trapezoides* but wanted to retain *iowana* as *trapezoides* had been misused by earlier authors. No one has followed him in that. BOUCHÉ (1969) added *arverna* on French material. Meanwhile, *arnoldi* was synonymized with *A. tuberculata* EISEN 1974 and *molita* with *A. turgida* EISEN 1874 so there are currently five species recognized in the *caliginosa* complex by English authors, others have ignored the whole complex.

The only differences between *caliginosa* and *trapezoides* was formerly that the tubercula pubertatis was a single band in xxxi—xxxiii in *trapezoides* while it was bipartite in *caliginosa*, EVANS, GATES and CAIN argued that there were also differences in the number of segments, extension of the glandular tumescenses around the male pores, position of the first dorsal pore, position of the genital markings and extension of the clitellum and tubercula pubertatis. These characters have been summarized for the five species in Table 6. For comparison the same data are included for the South African *trapezoides*.

The number of segments are 200—250 in *nocturna* and 115—194 in the other four species (121—162 in South African material). The first dorsal pore is in 8/9 to

Table 6 Comparison of external characters in the "species" of the *Caliginosa* complex

Name	Length	Width	Segments	Dorsal pore	Male porophores	Clitellum	Tubercula pubertatis	Genital markings in ab
A. iowana = *Trapezoides*	60—90	4	120—170	8/9, 9/10	$^1/_2$14—$^1/_2$16	27, $^1/_2$27—34	31—33, bands	9—11, 30—34
A. nocturna	90—180	4—6	200—250	8/9, 9/10	Small, slightly into 14, 16	$^1/_2$27, 28—$^1/_2$35	31, 33, extending over 32 but bipartite	9—12, 29, 30, 32—34
A. arnoldi = *Tuberculata*	55—100	4—6	146—194	10/11, 11/12, 12/13	?	27, 28—34, $^1/_2$35	31—33 bipartite	9—11, 30, 32, 34, 36, 37; on 36 in 20 %, on 37 in 2 %
A. molita = *Turgida*	65—81	3.5	136—140	?? 12/13 ? 12/13	?	$^1/_2$28, 28—34	30—33, single (type) or quadripartite	9—11, 32—34
A. caliginosa sensu GATES	35— 85	1.5—4.5	125—168	?	?	28, $^1/_2$28, 29—34, $^1/_2$35	?	9—11, 30, 32—34
A. arverna	80—100	6	115—130	9/10, 10/11	1/3, 14—16/17	$^1/_n$26—34	$^1/_2$31, 2/3, 31—33 single ridge	9—11 (9—12), 27—34
A. trapezoides South Africa	40—135	3.5—5	121—162	4/5—12/13	15 or slightly into 14, 16	26, 27, 28, 29—31, 32, 33, 34, 35	Absent or 28, 29, 30, 31—30, 31, 32, 33, 34	9—11 (9—12) only or 9—11, 26—32

12/13 in the five species and is overlapping. A difference of one segment cannot be regarded as of specific importance when definitive dorsal pores in the South African *trapezoides* was found in 4/5—12/13. The variation of the extent of the clitellum and the tubercula pubertatis, as well as the length of these organs, was much greater in a single South African population of *trapezoides* than in all the five species put together. However, the tubercula, when present, were always single bands without any interruption in all the South African worms. GATES (1953) and other authors on the other hand have described all intermediate forms between a single and a multiple origin of the tubercula. According to GATES *caliginosa*, *tuberculata* and *turgida* should be distinguished from each other in the position of the genital markings; they are absent on xii and xxxiii in *tuberculata*, present on xxxii, xxxiii in *turgida* and absent on xxxvi (and present on xii) in *caliginosa*. The South African worms, or at least most of them, would have to be described as a new species if the diagnoses of EVANS, CAIN and Gates are accepted as the following analysis show. Most South African specimen lacked genital markings on xii which rule out *nocturna* (the latter also have a higher number of segments than the South African worms). The single origin of the tubercula rules out *tuberculata* and absence of genital markings on xxxiii and xxxiv rules out *trapezoides* and *caliginosa*. Most South African specimens differ also from *trapezoides* in the position of the first dorsal pore, extension of the tumescences around the male pores and extension and segmental position of the tubercula pubertatis. The T28 population had the same arrangement of the genital markings and of the clitellum as *arverna* but differ in the position of the tubercula and of the first dorsal pore and in being unpigmented. In having the first dorsal pore in 4/5 this population could only be identified with *A. georgii* MICHAELSEN 1890, another species confused with *caliginosa*. They differ, however, from this species in the shape of the tubercula, possibly in the position of the clitellum and in the presence of genital markings on clitellar segments. Is seems to me that the position of the first dorsal pore varies with the environment. In South Africa the pores are present further forward in worms from dry than from wet soils.

ČERNOSVITOV's record "South Africa, Hoffnung east of Windhof" is somewhat misleading. Hoffnung is a small railway station 10—12 miles east of Windhoek in Namibia (REINECKE, in litt.).

2.3.3. *Bimastos eiseni* (LEVINSEN) 1844)

"*Lumbricus eiseni*", GATES 1968: 1—9, Table 1. (Excluded from *Bimastos* but not placed generically)

Previous records: Cape Province, Cape Peninsula, Kirstenbosch and Table Mt., Brockenhurst, Queen's Bower (GATES 1968).

Distribution: In M region. There is a big botanical gardens at Kirstenbosch. First collected in 1925. Original home probably Europe or adjacent parts of Asia.

2.3.4. *Bimastos parvus* (EISEN) 1874

Allolobophora parva, MICHAELSEN 1899a: 97
Bimastus parvus, SCIACCHITANO 1960: 12

Previous records: Cape Province, Port Elizabeth (MICHAELSEN 1899a); Table Mt., Wynberg cave (SCIACCHITANO 1960).

Distribution: In M and A regions. Original home probably Europe or U.S.A.

2.3.5. *Dendrobaena rubida* (SAV.) 1826
(2 specimens from 1 locality)

Helodrilus (*Bimastus*) *constrictus*, MICHAELSEN 1908: 41, 1913c: 552, 1913d: 62, 1913d: 62, 1913e: 448
Bimastus tenuis, PICKFORD 1937: 37
Dendrobaena rubida, JAMIESON 1967: 74—77, f. 4: D, Table 6 (tenuis morph).
Bimastos parvus (non EISEN), REINECKE & RYKE 1969: 520—521

Previous records: Cape Province, Cape Flats, Farm Bergvliet (MICHAELSEN 1908); Table Mt. and Knysna, main forest (MICHAELSEN 1913c and 1913d); Table Mt., Skeleton Gorge (PICKFORD 1937); Great Berg River at Cecilia's Drift above Paarl (JAMIESON 1967).
Natal, Howick, at foot of the Umgeni Falls (MICHAELSEN 1913e).
New records: Cape Province, Cape Town. 1872. Capt. G. DE VYLDER leg. Det. E. PERRIER as *H. (D.) subrubicunda* (RM No. 85). 0-4-3. C3, Heidelberg, in a garden. Limey, wet soil. 21. ii. 67. P. DE KOCK. 0-0-2.

External: Length 37—42 mm. Width 1.0—1.5 mm. Colour dark red, fading posteriorly, extending down to about $^1/_2$ BC where the pigmentation ends very abruptly. Number of segments 99, 100. Prostomium epilobous about $^1/_2$, tongue open. First dorsal pore in ?5/6 (filled with coelomic fluid) or ?7/8.

Clitellum saddle-shaped extending down to $^1/_2$ BC, intersegmental furrows distinct on xxv, xxvi, xxvii, to xxxi, xxxii. Tubercula pubertatis absent (1, C3) or present on xxix—xxxi but very indistinct on the right side (1, C3) or tripartite, rather big ridges on xxviii—xxx (3, Cape Town). Male pores slit-like, equatorial and just above B. Glands associated with the male pores absent (1, C3) or small, round, confined to xv (1, C3 and Cape Town).

Internal: Pigments dense in longitudinal muscle layer at mD. Typhlosole ends abruptly in lx (worm with 100 segments) or lxxvii (99 segments) leaving 22 and 40 posterior atyphlosolate segments. The typholosole was rather thin and deep. Nephridia very big and N-looped.

Seminal vesicles in xi, xii. Spermathecae absent.

Gut content: Loose soil with some to much organic matter (C3).

Distribution: From M, K and D regions. JAMIESON's worms were collected in streams or rivers. Except for Howick and Heidelberg the localities are clustered around Cape Town.

Remarks: All previous records and C3 are referable to an athecal morph usually called *tenuis*. The specimens from Cape Town were not dissected but on external characters they resemble the subrubicunda morph.

2.3.6. *Eisenia foetida* (SAV.) 1826 (Table 7—9)
(ca. 168 specimens from 2 localities)

Allolobophora foetida, MICHAELSEN 1891: 205
Eisenia foetida, MICHAELSEN 1908: 41
Helodrilus (*Eisenia*) *foetidus*, MICHAELSEN 1913c: 551

Previous records: Cape Town (MICHAELSEN (1891);
Cape Flats, Farm Bergvliet (MICHAELSEN 1908 and 1913c).

New records: Cape Province, Cape Town. 17. i. 1872. G. DE VYLDER. Det. E. PERRIER as *H.(D.) subrubicunda*. 10-0-2 (RM)

T 1, Roodeport. In a garden. Brown soil and manure. 4. iii. 67. AJR. 0-0-18

T 10, Pietersburg, Boomstraat 99. "Earthworm farm of Mr. Rossouis". 10. vii. 67. AJR. About 150 adult worms.

External: Length 41—74 mm. Width 2.8—3 mm. Pigmented dark red with yellow, intersegmental bands. Number of segments (18) 73—123, mean 104.5. Prostomium epilobous. First dorsal pore in ?4/5 (3), 4/5 (9), ?5/6 (2) and 5/6 (1). In one specimen dorsal pores could not be found in front of 11/12.

Clitellum (Table 7) saddle-shaped on xxv, xxvi, xxvii to xxxii, xxxiii covering 5.5 to 7 segments. In two worms was the lower margin of the clitellum one segment shorter than the upper one. Tubercula pubertatis (Table 8) as thin bands or low ridges below C on $^1/_2$xxviii, xxix to $^1/_2$xxx, xxx, xxxi, $^1/_2$xxxii covering two to four segments.

Internal: Typhlosole thin and rather deep, usually ends abruptly but sometimes diminish in size in the last few segments. It ends (Table 9) in lxv to cxiii leaving 8—15 posterior atyphlosolate segments.

Abnormality: In one worm was the tubercula pubertatis on xxix—$^1/_2$xxxi left and xxviii—$^1/_2$xxxi right.

Table 7 Position of the clitellum in *Eisenia foetida*

Position	Number of specimens
25—32	2
$^1/_2$26—$^1/_2$32	1
$^1/_2$26—$^1/_2$33	1
26—$^1/_2$32	4
26—32	3
26—33	1
27—$^1/_2$32	1
27—32	4

Table 8 Position of the tubercula pubertatis in *Eisenia foetida*

Position	Number of specimens
1/2 28—1/2 30	2
1/2 28—30	2
1/2 28—1/2 31	3
1/2 28—31	2
1/2 28—1/2 32	1
28—30	1
28—1/2 31	3
28—31	2
29—31	1

Table 9 Ending of typhlosole in *Eisenia foetida*

Number of segments	Ending of typhlosole	Atyphlosolate segments
73	65	8
88	79	9
94	89	5
98	90	8
99	84	15
100	89	11
100	93	7
103	101	2
106	99	7
107	95	12
107	99	8
107	101	6
110	101	9
112	100	12
113	104	9
123	110	13
123	113	10
Range:	65—113	2—15
Mean:	94.823	8.882

Distribution: From M, Sn and B regions. All records, with the possible but unlikely exception of Farm Bergvliet were from gardens. The T10 worms were bought from Ohio but was apparently only sold in a dried (dead) condition. First collected in 1872. Original home Europe or adjacent parts of Asia.

2.3.7. *Eisenia hortensis* (Mich.) 1890

Allolobophora veneta v. *hortensis*, Michaelsen 1899a: 97
Eisenia veneta var. *hortensis*, Michaelsen 1913c: 551

Previous records: Cape Province, Port Elizabeth (Michaelsen 1899a); Cape Town (Michaelsen 1913c).

Distribution: From M and A regions, from gardens. First collected in about 1898. Original home Europe or adjacent parts of Asia.

2.3.8. *Eisenia rosea* (Sav.) 1826 (Fig. 3—5, Table 10—15)
(175 specimens from 9 localities)

Enterion roseum Savigny 1826: 182 (Types, two, in PM. Type locality Paris)
Allolobophora rosea + *A. r. macedonia* Rosa 1893: 428 (Type locality for *macedonica*, Macedonia)
Allolobophora rosea, Bretscher 1900: 39—40
Eisenia rosea + *E. r.* var. *macedonica*, Michaelsen 1900: 478—479
Eisenia rosea f. *bimastoides* Cognetti 1901: 17—20 (Type locality Sardinia, Sassari, in a garden under a stone. November 1900—May 1901. Leg. L. Cognetti, Many specimens)
Eisenia rosea, Cognetti de Martiis 1901: 10
Helodrilus (*Bimastus*) *bimastoides*, Michaelsen 1903a: 130 (transfered from *Eisenia*)
Eisenia rosea (f. typica + f. *bimastoides*), Cognetti de Martiis 1905: 107—108
Eisenia rosea, Southern 1907: 78 (f. *macedonica*, GM)
Helodrilus (*Bimastus*) *indicus* Michaelsen 1907: 188 (Types presumably in IM, type locality Calcutta. Leg. N. Annandale, presumably several specimens)
Eisenia rosea, Michaelsen 1909: 63—64, f. 111
Eisenia rosea (part., excl. var. *croatica* & var. *budensis*), Szüts 1909: 128—129, 147—148, f. 10
Eisenia rosea + *E. r.* var. *macedonica*, Piguet & Bretscher 1913: 168—169
Helodrilus (*Eisenia*) *roseus* f. typicus & f. *bimastoides*, Chinaglia 1913: 7—8
Helodrilus (*Eisenia*) *roseus*, Michaelsen 1913c: 551 (South Afr. record)
Helodrilus (*Eisenia*) *roseus*, Smith 1917: 165—166
Helodrilus (*Eisenia*) *roseus* + *H.* (*E.*). *r.* var. *macedonica*, Ude 1922: 156
Helodrilus (*Allolobophora*) *prashadi* Stephenson 1922: 440—441 (Types in BM (NH), type locality Kashmir, ponds in the course of a shallow irrigation streamlet. Alt. about 6000 ft. Leg. B. Prashad 14 June, 1921, several specimens)
Allolobophora (*Eisenia*) *rosea*, Hertling 1923: 212—216, Table 8, 9. pl. 6: 16—19 (Typhlosole)
Allolobophora (A.) *prashadi* + *A.* (*Bimastus*) *indica*, Stephenson 1923: 501—502 + 506
Helodrilus roseus, Green 1923: 125—128, f. 1—2 (Abnormality)
Helodrilus roseus, Smith 1924: 32, pl. 6: 41—43, 9: 64 (calciferous glands)
Allolobophora (*Eisenia*) *rosea*, *Pickford* 1926: 227, 230 pl. 4: 2A—D (typica + *macedonica*)
Eisenia rosea, Ude 1929: 116—117, f. 160
Eisenia rosea typica + *E. r.* f. *bimastoides* + *E. r.* var. *macedonica* + *Allolobophora prashadi* + *Bimastus indicus*, Cognetti de Martiis 1931: 378, 424 + 379, 424 + 379, 426 + 391, 423 + 409, 426
Eisenia rosea, Michaelsen 1933: 429 (South African record)

Eisenia rosea var. *Štorkani* ČERNOSVITOV 1934: 74 (Type locality Bulgaria, Belasica-Planina. Leg. J. Štorkan 2 July, 1933. 0-0-2)
Eisenia rosea f. typica, ČERNOSVITOV 1935: 37
Eisenia rosea, PICKFORD 1937: 37 (South African record)
Eisenia rosea f. typica, TÉTRY 1937: 143—144 (Re-examination of types)
Eisenia rosea f. typica + *E. r.* var. *Štorkani*, ČERNOSVITOV 1937: 79—80 + 80
Eisenia rosea f. typica, TÉTRY 1939: 219—221, f. 35: A—B
Eisenia rosea f. *bimastoides*, KHALAF EL-DUWEINI 1940: 114—115, pl. 5: 3
Eisenia rosea f. typica + f. *macedonica* + *Allolobophora hataii* + *A. harbinensis* + *A. dairensis* + *A. jeholensis* KOBAYASHI 1940: 285—287 + 288—289, f. 4—5 + 290—291, f. 6—7 + 291—293, f. 8—9 + 293—295, f. 10a—d, 11 (type loc. for *hataii* MANCHUKUO, Chinhsien or Tashihchiao (not designated); for *harbinensis* Harbin; for *dairensis* Dairen; for *jeholensis* Jehol, Chihfen)
Eisenia rosea ? var. ČERNOSVITOV 1940: 441
Eisenia rosea f. typica + *E. r.* var. ? + *E. r.* var. *balcanica* ČERNOSVITOV 1941: 222—223 + 223 + 223—224 (Types in BM (NH), type locality Yugoslavia, Ivanec. Leg. K. GAVRILOV 13 May 1937. 21 specimens)
Eisenia rosea f. typica, ČERNOSVITOV & EVANS 1947: 22—23, f. 7
Allolobophora rosea f. typica (part., excl. *A. acystis* MICH.), POP 1947a: 10—11
Allolobophora rosea f. typica + *A. r.* f. *bimastoides* (part., excl. *Dendrobaena riparia* & *D. diomedaea*), POP 1947b: 90—93, 93—94
Allolobophora rosea f. typica, POP 1948: 451—453, f. 32
Eisenia rosea, JULIN 1949: 16, f. 4: 4, 10, map 3
Eophila kulagini MALEVIČ 1949: 460 (type locality Southern Kirgistan, in a forest. 0-0-1)
Eisenia rosea f. *dendrobaenoides* OMODEO 1950: 5—8
Eisenia rosea + *E. r.* var. *macedonica*, MULDAL 1952: 64—65 + 65 (Caryology)
Eisenia rosea typica + *E. r. dendrobaenoides*, OMODEO 1952a: 178—181, f. 1—2, pl. 14: 2 + 181—184, pl. 14: 3 (Caryology)
Eisenia rosea f. *acystis* OMODEO (non MICHAELSEN 1902) 1952b: 9
Eisenia rosea + *E. jenensis* FÜLLER 1952/53: 52, 56 + 57—58 (type locality Germany, Jena)
Eisenia rosea var. *macedonica*, ROOTS 1953: 43—44
Allolobophora rosea, GRAFF 1953: 64, 1 f., 1 photo on p. 65
Eisenia rosea, OMODEO 1953: 45—46 (Caryology)
Allolobophora rosea typica, OMODEO 1955: 143—144, Table 2
Allolobophora rosea, OMODEO 1956b: 334
Eisenia rosea, GATES 1956: 9, 26
Allolobophora rosea rosea, BALTZER 1956: 359—360, 366—367, f. 4: 4
Allolobophora rosea lusitana GRAFF 1957: 301—302, f. 2 (Type locality Portugal. 0-0-2)
Eisenia rosea, GATES 1958a: 41—42, 1958b: 6—8
Eisenia rosea, MURCHIE 1958: 113—131, f. 1—5 (ecology, life-history)
Allolobophora rosea ZAJONC 1959: 152, f. 4
Eisenia rosea f. typica, LEE 1959: 362—363
Allolobophora rosea f. *acystis* ad *bimastoides* OMODEO 1959: 6—7
Allolobophora rosea var. OMODEO 1962a: 6—7
Allolobophora (A.) *rosea*, OMODEO 1962b: 90
Allolobophora rosea, PLISKO 1963: 428—429, Table 2
Allolobophora rosea f. typica + *A. r.* f. *macedonica*, GERARD 1964: 32—33 + 33, f. 7, 10c
Allolobophora rosea rosea, POP 1964: 110

Allolobophora rosea, Omodeo 1964: 83
Allolobophora rosea, Bösener 1964: 240—241
Allolobophora rosea f. typica + *A. r.* f. *bimastoides* + *A. r.* f. *interposita*, Plisko 1965: 409 to 416, Table 1—2, f. 1—10 (type locality for interposita Poland, no firther data given)
Allolobophora rosea + *A. r.* var. *bimastoides*, Zicsi 1965: 172, 174, 193—194, f. 51
Eisenia rosea, Bhatti 1965: 16
Eisenia rosea, Perel 1967: 104—105, Table 5
Allolobophora rosea f. typica + *A. r.* f. *interposita* + *A. r.* f. *bimastoides*, Wilcke 1967: 128, pl. 21: 13
Allolobophora rosea f. *alpina*, Vedovini 1968: 793—796, f. 1—2 Type-locality Basses-Alpes, St.-André les Alpes. Alt. 1400 m. A. Vedovini. 0-0-8)
Allolobophora rosea rosea + *A. r. bimastoides*, Pop 1968: 235—236
Allolobophora rosea f. *baleanica* + f. *diomedea* (non Cognetti 1906), Karaman 1969: 81 to 82 + 82
Eisenia rosea, Reinecke & Ljungström 1969: 106—111 (ecology, South Africa)
Allolobophora rosea, Stop-Bowitz 1969: 188—191, f. 11—13

Previous records: Cape Province George (Michaelsen 1913c), Uitenhage (Michaelsen 1933), Paradise Estate near Kirstenbosch (Pickford 1937)
Transvaal, Potchefstroom (Reinecke & Ljungström 1969).
New records:

C 38, East London distr., about 7 mi from E. London on the Butterworth road. At Quenera river. 25. x. 67. POL & AJR. 1-0-1
C 44, King Williams Town distr., 26.6 mi from Kidd's Beach on the King William Towns road. Sandy, brownish, dry soil. 26. x. 67. POL & AJR. 0-0-2
C 47, King Williams Town distr., Debe Nek (about 16 mi from K.W.T. on Alice-road). Kommitjie flats. Grass field at small dam. Wet, black soil. 27. x. 67. POL & AJR. 0-0-1
T 2, Potchefstroom, near flooded area of Mooi river. Willow trees. 13. ii. 67. POL & AJR. 0-0-5
T 3, Potchefstroom, Rhodes plot. Old fruit garden. 2. ii. 67. POL & AJR. 0-0-2. 12. ix. 67. POL. 33-1-15 (includes nearby ditch)
T 4, Potchefstroom, Eucalyptus plantation. 3. ii. 67. POL & AJR. 0-0-7. 8. iv. 68. POL & AJR. 0-0-9
T 5, Potchefstroom, near Baily Park. Brown soil in vlei. 3. ii. 67. POL & AJR. 50-0-13
T 6, Potchefstroom, Oude Molen sports ground. At ditch. Blacksoil. 13. ii. 67. POL & AJR. 0-0-2
T 7, Potchefstroom, Mooi river, in riverbed. Kikuyu-grass. 2. ii. 67. POL & AJR. 0-0-12 ("long" form) 0-0-30 ("short" form)

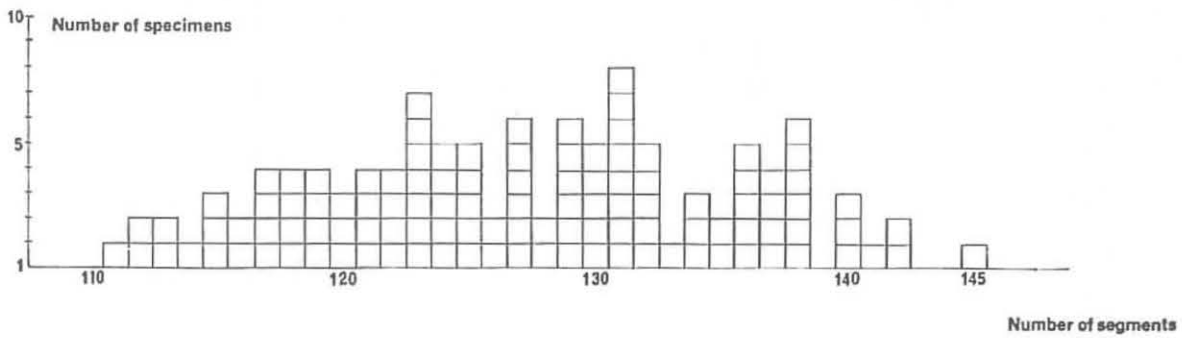

Fig. 3. Number of segments in *Eisenia rosea*.

External: Length 40 to 50 mm (normal form), 75—80 mm ("long" form, T7). Width 3—4 mm. Unpigmented white (all). Number of segments (Fig. 3) 84, 98, 111—142, mean (67), 121.4; juveniles 97—145, mean (51), 126.5, mean of adultes and juveniles (118), 124—0. Segments usually triamulated from xvi backwards. Prostomium epilobous (1/ to 1/3). First dorsal pore in ?4/5 (1), 4/5 (41), ?5/6 (4), 5/6 (27), ?6/7 (2) and 6/7 (16).

Clitellum (Table 10) saddleshaped to B, on 1/2xxiii, xxiv, xxv, xxvi, xxvii, xxviii to xxxi, xxxii, xxxiii, xxxiv, xxxv, covering 6 to 9.5 segments. In many adolescent worms the ventral surface of clitellar segments becomes swollen before the clitellum begins to develop. This swelling did not seem to be glandular. Tubercula pubertatis either absent (8) or present (81) as straight, rather faint bands above B, on xxvii, xxviii, xxix, xxx, xxxi, xxxii to xxxii, xxxiii, xxxiv, covering one to four segments (Table 11). Male pores round, minute slightly above B and equatorial. The

Table 10 Position of the clitellum in *Eisenia rosea*

Position	Number of specimens
1/2 23—32	2
24—31	2
24—32	2
1/2 25—32	26
25—32	22
26—32	1
26—33	2
27—32	2
27—34	2
28—35	1
1/2 28—35	1

Table 11 Position of the tubercula pubertatis in *Eisenia rosea*

		Abnormal specimens		
Position	Number of specimens	Left	Right	Number of specimens
absent	8	28—29	29—1/2 31	1
27—30	2	28—32	28—30	1
28—30	1	29—30	absent	1
29—30	2	29—1/2 31	absent	1
29—1/2 31	24	30—31	29—1/2 31	1
29—31	42			
1/2 30—1/2 31	1			
30—32	3			
31—33	2			
32—34	1			

Table 12 Ending of typhlosole in *Eisenia rosea*

Number of segments	Ending of typhlosole	Atyphlosolate segments
117	87	30
119	90	29
123	99	24
123	99	24
123	99	24
123	99	24
124	99	25
127	105	22
128	100	28
131	104	27
131	109	22
132	103	29
132	106	26
137	112	25
138	107	31
141	115	26
142	119	23
Range: 117—142	87—119	22—31
Mean:	103.0	24.6

Data from HERTLING 1923 (number of specimens in brachets)

Number of segments	Beginning of typhlosole	Ending of typhlosole	Atyphlosolate segments
Range: 109—139 (21)	19 (21)	92—108 (20)	13—31 (20)
Mean:	19	98.1	25.3

male pores are usually situated in the middle of a glandular swelling wich is sometimes confined to xv but can often extend over $^1/_2$xiv to $^1/_2$xvi or be totally absent.

Genital markings absent in all specimens except five from T4. On these worms there are small round papillae in AB of xvi (5) and in addition on xxiv-xxxii (1), xxv—xxxii (2), xxvii—xxxii (1) and xxix—xxxii (1).

Internal: Seminal vesicles in ix—xii, their size increasing backwards (7 from quadrithecal) or in xi, xii (13 from quadrithecal, 1 from bithecal and 5 from athecal morphs). Spermathecae (when present) small, round, situated near mD in x or in x, xi. The morphs are as follows: athecal (9), bithecal (1) and quadrithecal (20).

Typhlosole begins in xxii as a very thin ridge increasing in size to xxiv (1) where it reaches full size and ends abruptly (Table 12) in lxxxvii to cxix. Number of atyphlosolate segments varies between 22 to 31 with a mean of 24.6 segments.

Table 13 Comparison of described forms of *Eisenia rosea*

Name	Country	Segment	Size	Clitellum	TP	Genital markings	Spermathecae	Seminal vesicles	Reference
E. rosea	Bulgaria	120—156	42—82× 3—7	24, 25—32	29—31	cd 12, 24, 34	absent 10, 11	9, 11, 12; 11, 12	PLISKO, 1963: 428—442
A. rosea	Italian Alps							9, 11, 12 10, 11, 12	OMODEO, 1962: 6—7
E. rosea rosea	Roumania						absent	10, 11, 12	POP, 1964: 110
A. rosea	Austria			24, 25, 26—32, 33	28, 29—31	ab 9, 11, 12 24, 25, 26—32, 33	10, 11	9, 10, 11, 12, 9, 11, 12	ZICSI, 1965: 172, 194
E. rosea	Liguria						absent	9, 10, 11, 12	COGNETTI DE MARTIIS 1905: 107—108
E. rosea	Ireland			25, 26—$^1/_2$32, 32	29—30, 31	absent; ab 9—12, 24, 25, 27—33			SOUTHERN, 1907: 78
A. rosea	Switzerland			25, 26—31, 32	28, 29, 30—31, 32				BRETSCHER, 1900: 40
E. rosea	Hungary			26, 27—31, 32, 33	28, $^1/_2$28, 29,30 — 31, 32	ab 9—12, 25, 26—31, 32	2 pairs		SZÜTS, 1909: 125
E. rosea	Pennsylvania	90—123	22—42× 3—4	25—32	29—31				BHATTI, 1965: 116
E. rosea	Transkaukasia			26—$^1/_2$33, 33	28, 29—$^1/_2$31, 31		absent, quadrithecal	10, 11, 12; 11, 12	PEREL, 1967: 106
A. rosea	ČSSR	63—170	47—202 ×1.1—6	23, 24, 25, 26, 27—31, 32, 33, 34	27, 28, 29 30—29, 30 31, 32				ZAJONC, 1959: 152
E. rosea	Argentina						absent	(9, 10, 11, 12)	COGNETTI DE MARTIIS, 1902: 10

A. rosea f. typica	Roumania	120—170	35—150 ×2—4	24, 25, 26—32, 33	29—31	ab 9, 11, 12, 24, 25, 26—32, 33	10, 11	9, 10, 11, 12	Pop, 1948: 451—45
E. rosea f. typica	Corsica			25, 26—32	29—31	ab 11, 12 cd 13	present	9, 10 (?11, 12)	Pop, 1947: 10—11
A. rosea f. typica	Poland	91—173	41—120 ×3—7	24, 25, 26—32, 33	29—31	ab 9, 10, 11, 12, 23, 24. cd 9—12. 23, 24	(10, 11)	9, 10, 11, 12, 9, 11, 12, 11, 12	Pliśko, 1965: 411, 414
A. rosea f. typica	Austria			24, 25—32, 33	$^1/_2$27, 28, 29—31	ab 8—13, 16, 24—33 cd 9—12	10, 11	9, 10, 11, 12 9, 11, 12; 10 11, 12; 11, 12	Pop, 1947: 90—93
E. rosea ? var.	Jordan	66	c:a 48	24—32	29—31	ab 16 cd 9, 10	absent	9, 10, 11, 12	Černosvitov, 194, 441
E. rosea var.	Egypt						absent	9, 11, 12	Černosvitov, 194, 223
A. rosea var.	Afganistan	115—146				ab 12, 15	9/10	9, 10, 11, 12	Omodeo, 1962: 6—7
						cd 9—12	absent	9, 11, 12	
E. rosea f. bimastoides	Sardinia			24—32	29—31, 28—30	ab 16	absent	11, 12	Cognetti de Martiis, 1901: 17—20
E. rosea f. bimastoides	Sardinia						absent	9, 11, 12(?)	Chinaglia, 1913
E. r. v. bimastoides	Bulgaria	86—96	72—76 ×6	26—32	29—31	ab 10, 16 cd 10, 12, 13	absent	11, 12	Černosvitov, 193, 80
A. r. f. bimastoides	Poland	71—137	20—48× 2—3.5	24, 25—31, 32	29—30	„as in typica"	absent	11, 12	Pliśko, 1965: 414
A. r. f. bimastoides	Austria				29—30		absent; vestigial	11, 12	Pop, 1947: 93
E. r. f. bimastoides	Algeria				29—31		absent	10 right, 11, 12	Pop, 1968: 235—23
E. r. f. bimastoides	France				29—31	cd 13		11, 12	Pop, 1968: 235—236
A. r. macedonica	Macedonia	130	70×4	26—33	(29—31)	ab 26—33	"as in typica"	"as in typica"	Rosa, 1893: 428

Continuation Table 13

Name	Country	Segment	Size	Clitellum	TP	Genital markings	Spermathecae	Seminal vesicles	Reference
E. r. f. macedonica	England		60×3	26—32	29—30	ab 26—32			ROOTS, 1953: 43—44
A. r. f. macedonica	Manchukuo								
E. r. v. dendrobaenoides	Calabria (Italy)	140—143	60×3	24, 25, 26—33	29—31	ab 9, 11, cd 9—12	10, 11	9, 11, 12	OMODEO, 1950: 5—6
E. r. v. dendrobaenoides	Italy	110—145	60—90×3.5—4	23, 24, 25—32—33	29—31	ab 9, 11, 16, clit. segm. cd 9, 11, 12	10, 11	9, 11, 12	OMODEO, 1952: 181 bis 182
E. r. v. balcanica	Croatia	95—144	75—95 × ?	24, 25—32	29—31	ab 9—12, 16 cd 9, 11, 12	10, 11	11, 12	ČERNOSVITOV, 1941: 223
A. r. f. balcanica	Macedonia	78—160	32—45 ×1.5—3	25—32, 33	29—"37" $^1/_2$27, 30—31				KARAMAN, 1969: 81—82
E. r. v. Storkani	Bulgaria	89—96	72—76 ×6	26—32	29—$^1/_2$31	ab 24—26	9, 10	9, 10, 11, 12	ČERNOSVITOV, 1934: 74
A. r. lusitana	Portugal	89—101	36—43×1.5—2.5	27—32, 33	1/n29—1/n32	absent	9, 10	9, 10	GRAFF, 1957: 301—302
A. r. f. interposita	Poland	71—160	20—60×2—4	24, 25, 26—32	29—$^1/_2$31	"as in typica"	9, 10	9, 10, 11, 12; 11, 12	PLISKO, 1965: 415—416
A. r. f. alpina	France	132—155	55—80×3—5	24, 25—33	27—31, $^1/_2$32	ab 9, 11, 14	9/10 10/11	9, 10, 11, 12	VEDOVINI, 1968: 793—796
A. r. acystis ad bimastoides	Afghanistan	115—145		24—32	29—31	ab 9, 22, 23 cd 10, 11, 12	absent	9, 10, 11, 12; 11, 12	OMODEO, 1959- 6—7
H. (B.) indicus	Calcutta	(87?—)—107	58—75×6	25—32	26—30	absent	absent	11, 12	MICHAELSEN, 1907: 188
A. (A.) parashadi	Kashmir	133	62×3	23, 24—32, 33	29, 31	ab 10, 11, 12	absent	9, 10, 11, 12	STEPHENSON, 1922: 440—441

A. rosea f. typica	Roumania	120—170	35—150 ×2—4	24, 25, 26—32, 33	29—31	ab 9, 11, 12, 24, 25, 26—32, 33	10, 11	9, 10, 11, 12	Pop, 1948: 451—45
E. rosea f. typica	Corsica			25, 26—32	29—31	ab 11, 12 cd 13	present	9, 10 (?11, 12)	Pop, 1947: 10—11
A. rosea f. typica	Poland	91—173	41—120 ×3—7	24, 25, 26—32, 33	29—31	ab 9, 10, 11, 12, 23, 24. cd 9—12. 23, 24	(10, 11)	9, 10, 11, 12, 9, 11, 12, 11, 12	Plisko, 1965: 411, 414
A. rosea f. typica	Austria			24, 25—32, 33	$^1/_2$27, 28, 29—31	ab 8—13, 16, 24—33 cd 9—12	10, 11	9, 10, 11, 12 9, 11, 12; 10 11, 12; 11, 12	Pop, 1947: 90—93
E. rosea ? var.	Jordan	66	c:a 48	24—32	29—31	ab 16 cd 9, 10	absent	9, 10, 11, 12	Černosvitov, 194, 441
E. rosea var.	Egypt						absent	9, 11, 12	Černosvitov, 194, 223
A. rosea var.	Afganistan	115—146				ab 12, 15	9/10	9, 10, 11, 12	Omodeo, 1962: 6—7
						cd 9—12	absent	9, 11, 12	
E. rosea f. bimastoides	Sardinia			24—32	29—31, 28—30	ab 16	absent	11, 12	Cognetti de Martiis, 1901: 17—20
E. rosea f. bimastoides	Sardinia						absent	9, 11, 12(?)	Chinaglia, 1913
E. r. r. bimastoides	Bulgaria	86—96	72—76 ×6	26—32	29—31	ab 10, 16 cd 10, 12, 13	absent	11, 12	Černosvitov, 193, 80
A. r. f. bimastoides	Poland	71—137	20—48× 2—3.5	24, 25—31, 32	29—30	„as in typica"	absent	11, 12	Plisko, 1965: 414
A. r. f. bimastoides	Austria				29—30		absent; vestigial	11, 12	Pop, 1947: 93
E. r. f. bimastoides	Algeria				29—31		absent	10 right, 11, 12	Pop, 1968: 235—23
E. r. f. bimastoides	France				29—31	cd 13		11, 12	Pop, 1968: 235—236
A. r. macedonica	Macedonia	130	70×4	26—33	(29—31)	ab 26—33	"as in typica"	"as in typica"	Rosa, 1893: 428

Continuation Table 13

Name	Country	Segment	Size	Clitellum	TP	Genital markings	Spermathecae	Seminal vesicles	Reference
E. r. f. macedonica	England		60×3	26—32	29—30	ab 26—32			ROOTS, 1953: 43—44
A. r. f. macedonica	Manchukuo								
E. r. v. dendrobaenoides	Calabria (Italy)	140—143	60×3	24, 25, 26—33	29—31	ab 9, 11, cd 9—12	10, 11	9, 11, 12	OMODEO, 1950: 5—6
E. r. v. dendrobaenoides	Italy	110—145	60—90×3.5—4	23, 24, 25—32—33	29—31	ab 9, 11, 16, clit. segm. cd 9, 11, 12	10, 11	9, 11, 12	OMODEO, 1952: 181 bis 182
E. r. v. balcanica	Croatia	95—144	75—95×?	24, 25—32	29—31	ab 9—12, 16 cd 9, 11, 12	10, 11	11, 12	ČERNOSVITOV, 1941: 223
A. r. f. balcanica	Macedonia	78—160	32—45×1.5—3	25—32, 33	29—"37" $^1/_2$27, 30—31				KARAMAN, 1969: 81—82
E. r. v. Storkani	Bulgaria	89—96	72—76×6	26—32	29—$^1/_2$31	ab 24—26	9, 10	9, 10, 11, 12	ČERNOSVITOV, 1934: 74
A. r. lusitana	Portugal	89—101	36—43×1.5—2.5	27—32, 33	1/n29—1/n32	absent	9, 10	9, 10	GRAFF, 1957: 301—302
A. r. f. interposita	Poland	71—160	20—60×2—4	24, 25, 26—32	29—$^1/_2$31	"as in typica"	9, 10	9, 10, 11, 12; 11, 12	PLISKO, 1965: 415—416
A. r. f. alpina	France	132—155	55—80×3—5	24, 25—33	27—31, $^1/_2$32	ab 9, 11, 14	9/10 10/11	9, 10, 11, 12	VEDOVINI, 1968: 793—796
A. r. acystis ad bimastoides	Afghanistan	115—145		24—32	29—31	ab 9, 22, 23 cd 10, 11, 12	absent	9, 10, 11, 12; 11, 12	OMODEO, 1959- 6—7
H. (B.) indicus	Calcutta	(87?—)—107	58—75×6	25—32	26—30	absent	absent	11, 12	MICHAELSEN, 1907: 188
A. (A.) parashadi	Kashmir	133	62×3	23, 24—32, 33	29, 31	ab 10, 11, 12	absent	9, 10, 11, 12	STEPHENSON, 1922: 440—441

A. hataii	Manchukuo	134—142	78—97× 2—3	24—32	29—31	ab 9, 15, 16, 25—32 cd 10, 11, 12	9, 10	9, 10, 11, 12	KOBAYASHI, 1940:290—291
A. harbinensis	Manchukuo	134—144	76—96× 2.7—3.3	25, 26—32, $^1/_2$33	29—31	ab 9, 12, 27—32; cd 9, 10, 12	9, 10	9, 10, 11, 12	KOBAYASHI, 1940: 290—291
A. dairensis	Manchukuo	137—139	80—111× 3.5—5.5	23—33	29—31	ab 9, 15, 16, 23—33	absent	9, 10, 11, 12	KOBAYASHI, 1940: 291—293
A. jeholensis	Jehol	132—140	41—53× 4—4.6	23—32, 33	29—31	ab 15, 16, 23—32 cd 9—12	absent	9, 10, 11, 12	KOBAYASHI, 1940: 293—295
Eo. kulagini	Kirgistan	125	65× 3—4	23—33	29—31	absent	10, 11	11, 12	MALEVIČ, 1949: 398
E. jenensis	Germany	109—155	60—75× 2	24, 25—32	29—30	ab 25, 26—32	10, 11	9, 10, 11, 12	FÜLLER, 1952/53: 52

Abnormalities: In five specimens the tubercula pubertatis showed some segmental abnormalities being present on the left side only (2) or the left one having a different position from the right one (3) (Table 11). In one quadrithecal worm the seminal vesicles were present in ix left (vestigial), and paired in xi, xii.

Reproduction: No iridescence was ever found on male funnels or spermathecae. The spermathecae were always empty. It is safe to conclude that the South African worms are parthenogenetic which is also the case with European and American material.

Regeneration: Two anterior amputees were found at T 4 on April 8. Both worms were active but several of the other specimens were in diapause.

Both worms had the male pores on "iv" and must thus have lost the anterior eleven segments. Prostomium was almost completely developed and normal and no trace of the wound was found. Their guts were full with soil. Although both specimens had lost all internal genital organs) neither seminal vesicles of xii nor ovaries was found) they were apparently still healthily alive.

Distribution: From A, SE, E, and Sn regions. This species is the most common lumbricid in South Africa. First collected in 1911. Original home Europe or adjacent parts of Asia.

Remarks: Somatic anatomy was only examined in a few specimens and was found to be uniform and in agreement with previous descriptions.

In several specimens from 17 the seminal vesicles had each many dark, brown to black bodies. These "bodies" were made up of debris and one to two setae. They were most frequent in older worms.

Review of morphology: Length of typica varies between 35—150 mm in Roumania (POP 1948: 451—453) and between 47—202 mm in Czeckoslovakia (ZAJONC 1959: 152), from other localities 41—82 mm has been reported. Length of all other forms are within this range with the exception of *interposita* which is 20—60 mm. The width is 2—7 mm in typica, the only form being outside this range is *lusitana* which is 1.5—2.5 mm. All forms synonymized here are unpigmented white with a rather transparent body-wall. The clitellum is always white. KOBAYASHI (1950) said that his worms were grey. PEREL (1967) records traces of purple pigment in the anterior segments of *rosea*. In life this species is light red (hence the name) due to capillaries in the body-wall. The number of segments is 63—170 in typica, 71—137 in *bimastoides* and below 100 in several of the other forms (see Table 13). OMODEO (1959) gives the mean of Afghan worms as 135 compared to 121 found in the present investigation. *E. rosea* is a surface-dwelling species that is heavily preyed on by birds. This will often lead to the loss of the tail and the records of segment number which are under one hundred might be recent amputees. I have found no indications in the papers that only un-amputated worms were used and it is possible that previous author were not aware of this phenomenon. It should be noted that young worms usually have a higher number of segments than adult ones. The high mean figure given by OMODEO is. perhaps, partly explained by the fact that many of his worms were collected in

caves. Segments bi- or triannulated between the male pores and the clitellum in typica and all other forms for which it has been recorded. Prostomium epilobous (tongue open or closed, extension varies) in typica and in all other forms except *halaii*, *dairensis* and *prashadi* where it is procpilobic. Pop (1968) describes some *bimastoides* from Algeria with a tanylobic prostomium. Setae are closely paired throughout the length of the worm in all forms (Table 14). Nephropores minute, axial level never recorded. First dorsal pore in 4/5 in all forms except in *dendrobaenoides* where it is supposed to be in 3/4 (with a pore-like marking in 2/3) or 4/5 (with a pore-like marking in 3/4). *E. rosea* ?var. from Jordan in 6/7, *indicus* in 5/6, *bimastoides* from Bulgaria in 5/6 (Černosvitov 1937), Štorkani in 6/7 and *lusitana* in 5/6. In the latter form they should be invisible on the clitellum. Usually the pores are functional and clearly visible also here but when the worms are poorly preserved they can be invisible and the same may apply to the first few pores as well. This was the case with those worms reported on in this paper which had the first dorsal pore behind 4/5 and the same was the case with at least some of the worms reported to have the first pore behind 4/5 in earlier papers. Sometimes small dots or marks can be found at mD before the real first dorsal pore. Such marks might have lead Omodeo to believe that the pore was as far forward as 3/4. Only in well-preserved material is it possible to determine what is a pore and what is only a weaking of the epidermis.

The clitellum is always saddle-shaped reaching to B, beginning on xxiii, xxiv, xxv, xxvi or xxvii and ending on xxxi, xxxii, xxxiii or xxxiv. In the South African material a few worms had the clitellum further back (Table 10). Tubercula pubertatis as bands or low ridges, beginning on $^1/_2$xxvii, xxviii, xxix or xx and ending on xxx, xxxi or xxxii in typica. Only in *bimastoides* (sometimes on xxix—xxx) and in *indicus* (on xxvi—xxx) is the extension of the tubercula outside the variation found in typica. In the South African material the tubercula was occasionally absent and in a few worms they were further posteriad than previously recorded (Table 11). Unfortunately my original notes are in Potchefstroom so it cannot be stated if this posteriad shifting of the tubercula occurs on the same worms as those with the posteriad clitella. Cognaglia (1913) noted a worm with the tubercula on xxv—xxx right and xxxii—xxxv left. Asymmetry in the position of the tubercula was also found by Zajonc (1959) and in the present investigation. However, in the great majority of the worms reported on previously and in this paper the tubercula were on xxix—xxxi. The number of segments covered by the tubercula shows much less variation and is three in practically all specimens examined, rarely covering only one segment (T3), two (*bimastoides* of some authors), four or five (typica from Austria, Pop 1947). Spermathecal pores, when present, are minute, superficial, intersegmental and situated in CD (*harbinensis* and *alpina*) or (all other forms) between D and mD, usually two pairs. Omodeo (1962a) found a specimen from Afghanistan with one pair of pores in 9/10 near mD and another one with a single pore in 9/10. Female pores, as in all other lumbricids,

Table 14 Setal ratios in *Eisenia rosea*. Data have, when possible, been recalculated so that cd = 1

		Preclitellar					Postclitellar					Remarks
		aa	ab	bc	cd	dd	aa	ab	bc	cd	dd	
A. rosea	ČSSR	16	1.3	8	1	26						Adults
		12	1.1	8	1	26						Juveniles
E. rosea f. *alpina*	France	?	1	7	1	$^1/_2$C						
E. rosea f. *balcanica*	Croatia	5	1.2	7.6	1	15	10	12	6	1	12	
A. rosea f. *balcanica*	Macedonia						7	1	4.5	< ab	$^1/_2$C	
E. rosea f. *dendrobaenoides*	Italy						7	1.2	4	1	1/3 C	
A. rosea f. *lusitana*	Portugal	2.5	1	1	1	1/3 C	3	1	2	1	1/3 C	
E. rosea v. *Štorkani*	Bulgaria	$1^1/_2$bc	= cd	?	= ab	$^1/_2$C					1/3 C	
A. dairensis	Manchukuo						13.8	1.3	6.3	1	22	
A. harbinensis	Manchukuo						16.5	1.3	7.5		29.6	
A. hataii	Manchukuo						19.2	1.4	9.1	1	35	
H. (B.) *indicus*	Bengal	5	1	5	1	15						
A. jeholensis	Jehol						6.7	0.6	3.8	1	13	

minute, paired. They are on eq/xiv at AB. Male pores, as in all other lumbricids, minute, paired. They are on eq/vx at AB or A. The pores are situated on middle of glandular tumescences that usually are confined to xv but can sometimes extend slightly over xiv and xvi or be absent (*alpina*). Genital markings (Fig. 4) are usually absent, if present they are small, round tumescences surrounding the setal couples (usually **a**, **b**). They are usually paired but in some populations some worms with unpaired, pre-clitellar, genital markings have been found (see e.g. PICKFORD 1926). They are usually situated at AB on ix—xii or part thereof and/or clitellar segments and less frequently in CD on ix—xii or part thereof. In addition, markings of AB

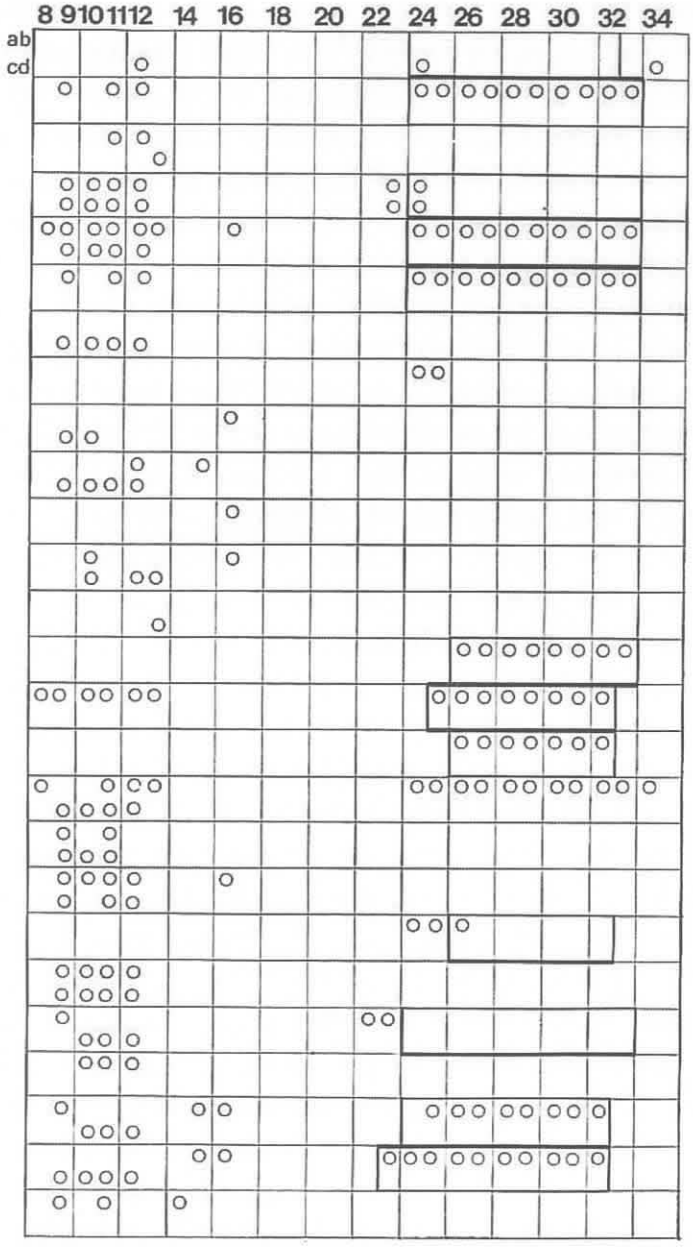

Fig. 4. Position of genital markings (rings) and the clitellum (lines) in *Eisenia rosea*.

have been found on viii, xv, xvi, xxiii and of CD on xiii, xxiii, xxiv and xxvi. Clitellar genital markings seems to be less frequent than preclitellar markings.
Internal: Pigments always absent from either muscle layer. Septa of anterior segments usually (?always) somewhat thickened. Septa 6/7—9/10 considerably, 10/11—14/15 slightly thickened (typica, Smith 1917), 5/6, 6/7—9/10, 10/11 thickened (European authors on typica), 6/7—8/9 moderately 9/10 slightly thickened (*hataii* and *harbinensis*), 5/6 slightly 6/7—9/10 moderately 10/11—11/12 slightly thickened (*dairensis*) and 6/7—9/10 moderately thickened (*jeholensis*). In Štorkani all anterior septa are said to be thin, in one South African worm 6/7—7/8 was noted to be thickened, other notes on this character are in Potchefstroom. In the Lumbricidae thickened septa are still rather thin (but opaque) compared to other families and the opinion on how thick a septum should be to be called thickened will of course vary with the observer. In macerated or soft worms septa will seem to be thinner than in well preserved ones and possibly the physiological state of the worms at the time of death have some influence on the septal thickness. There is no agreement or definition of what constitutes a thickened septa and measurements have never been made, but for the present any septum that is not transparent could be considered thickened. Statements such as "moderately", "considerably" and the like have of course no meaning whatsoever when more than on specimen is involved even if described by the same author, neither can any comparison be made between worms described by different authors. More useful, and probably more correct anatomically, would be to call the septa transparent, opaque and muscularized. Gizzard, as in most other lumbricids, in xvii—xviii (recorded for typica, *balcanica*, *dendrobaenoides* and Kobayashi's four species). Karaman (1969) describes some variation in the position of the crop and gizzard in *balcanica*. Calciferous sac in x, gland in xi—xiii. Number of lamellae 38—54 (Omodeo 1952). Intestinal origin never recorded. The typhlosoles begins in xix and covers about 80 % of the number of segments covered by the intestine, ending abruptly and leaving 13—32 posterior atyphlosolate (mean about 25) segments (Hertling 1923 and present investigation). There are six pairs of hearts in vi—xi. Other features of vascular system unknown. Nervous and nephridial system never described. The longitudinal musculature is pennate (recorded for typica and *lusitana*). The peculiar yellow mucocytes of typica have also been found in *bimastoides*, *prashadi* and *dendrobaenoides*. These mucocytes seems to be specific for *rosea*.

Testes and their funnels free in x, xi (all forms). Ovaries in xiii. Ovisac present. Seminal vesicles (Table 15) absent (typica from Bulgaria; *acystis* ad *bimastoides*), present in x (*lusitana*) or xi, xii (typica and *bimastoides* from Bulgaria and typica from Poland, Transcaucasia and Austria; *balcanica*; *indicus*; *kulagini*; South African forms) or ix, x (*acystis* ad *bimastoides*) or x, xi, xii (typica from Austria, Roumania, Transcaucasia and the Italian Alps) or ix, xi, xii (typica from Poland, Austria, Italian Alps, Bulgaria; E. r. ?var. from Egypt; A. r. var. from Afghanistan; *dendrobaenoides*)

or ix, x, xi, xii (typica from Europe, U.S.A.; *E. r.* ?var. from Jordan; *A. r.* var. from Afghanistan; *alpina*; *Storkani*; *interposita*; *prashadi*; *hataii*; *harbinensis*; *dairensis*; *jeholensis*; *jenensis*; *bimastoides* from Argentina; presumably *macedonica*; South African material). Genital setae about 0.8 mm long and 20 y thick in typica (ČERNOSVITOV 1935), 0.7 mm long in *hataii*, 0.8 mm on preclitellar and 0.5 mm on clitellar segments in *harbinensis*, 0.8 mm long on ix—xii, 0.6 on xv, xvi and 0.7 mm on clitellar segments in *dairensis*, 0.8 mm on ix—xii, 0.7 mm on xv and 0.6 mm on xvi and on clitellar segments in *jeholensis*. They are almost straight to slightly sigmoid, distal half to distal one-third grooved, end blunt to slightly pointed (KOBAYASHI 1940). Follicles of genital setae of **a**, **b** or **c**, **d** present and protruding into coelom in x—xiii and **a**, **b** in xxv, xxxii (U.S.A., GATES 1956: 9). They are also present in *hatai*, *harbinensis*, *dairensis* and *jeholensis*. Atrial glands lacking (Pennsylvania, BHATTI 1965: 16). Tubercula pubertatis glands present (Pennsylvania, BHATTI, l.c.) or absent (U.S.A., GATES, l.c.). Spermathecae (Table 15) absent (typica from Bulgaria, Roumania, Transcaucasia, Italy; *E. r.* ?var. from Jordan, Egypt; *A. r.* var. from Afghanistan; *bimastoides* from Sicily, Italy, Bulgaria, Poland, Austria, Algeria, Argentina; *acystis* ad *bimastoides*; *indicus*; *prashadi*; *hataii*; *harbinensis*; *dairensis*; *jeholensis*; South African material) or vestigial (quadrithecal) (*bimastoides* from

Table 15 Number of spermathecae and seminal vesicles and position of genital markings in *Eisenia rosea*

Spermathecae	Seminal vesicles	Genital markings
6	?	?
4	8	preclitellar + clitellar
4	8	preclitellar
4	8	clitellar
4	8	absent
4	6	preclitellar + clitellar
4	6	preclitellar
4	6	absent
4	4	preclitellar
4	4	absent
2	?	?
1	?	?
0	8	preclitellar + clitellar
0	8	preclitellar
0	8	absent
0	6	?
0	5	absent
0	4	preclitellar + clitellar
0	4	preclitellar
0	4	absent

Australia) or monothecal, spermatheca in ix (*A. r.* var. from Afghanistan) or bithecal, spermathecae in ix (*A. r.* var. from Afghanistan), or bithecal, spermathecae in x (South African material), or quadrithecal, spermathecae in ix, x (*Štorkani*; *lusitana*; *interposita*; *harbinensis*) or quadrithecal spermathecae in x, xi (typica from Bulgaria, ? Transcaucasia, Roumania, Poland, Austria; *dendrobaenoides*; *alpina*; *balcanica*; *kulagini*; *jenensis*; presumably *macedonica*; South African material) or sexthecal (U.S.A., GATES 1958a and in litt.). The spermathecae are small, round, with a very short duct and are situated above D and usually near mD. Hardly any records on variation of the vesicles or spermathecae are availably from Northern Europe. This is presumably due to the fact that earthworms from that part of Europa have been considered to belong to "well-known", peregrine species and was thus not dissected while worms from Southern Europe or extra-european territories might prove to belong to new species, thus they have been studied more thoroughly. Undoubtly, all forms here considered to be synonymous with *E. rosea* would be found in Northern Europe if zoologist would only care to dissect the worms. One piece of evidence is provided by the great variation found in roseas from Potchefstroom.

Caryology: Chromosome numbers for different morphs of *rosea* have been reported from England, Switzerland, France and Italy. The basic number is 18. Only one diploid form has been found, in France, *alpina* with 36 chromosomes. All the other morphs are polyploids: 3x = 54 (typica, from England, Switzerland, Naples), 4x = 72 (*dendrobaenoides* from Naples), 5x = 90 (typica from Messina), 6x = 108 (typica from Siena) and 10x = 160—174 (*dendrobaenoides* from Monte Pollino, Italy), *macedonica* has apparently lost one chromosome compared to *rosea*, and has 53 chromosomes. Data for *rosea* taken from MULDAL (1952) and OMODEO (1952a and 1955), for *dendrobaenoides* from OMODEO (1952d), for *macedonica* from MULDAL (1952) and for *alpina* from VEDOVINI (1968). OMODEO (1953) discuss the evloution of ploidy in *rosea* and believes that *rosea* with 3x is the basic form from which *macedonica* has evolved on the one hand and the other forms with higher ploidy on the other. The finding of VEDOVINI makes more probably, however, that the parent form for the different morphs of *rosea* were diploid and biparental (see below).

Distribution: All of Europe north into Fennoscandia north to about 64° N along the coast. British Isles. Iceland (Reykjavik). All of SSSR north to the taiga zone, south to Turkestan and northern parts of the Ala-tau and Tien-shan ranges and east to SW Siberia. Canary islands. Most Mediterranean islands. Morocco, Algeria, Libya, Egypt but only along the coast except in Egypt where it has been found in some oasis further inland. Israel, Jordan, Turkey, Afghanistan. India (Kashmir and Calcutta). Manchukuo, Jehol. Japan. U.S.A. from California to Maine. Southern Canada. Mexico (highland localities). Brazil (along the coast). Colombia, Peru and Chile (along the coast and highland localities). Uruguay (Montevideo). Argentina (central). South Africa (highland localities or in colder parts of the country). New zealand (North and

South Islands) and Chatham Island. Southern Australia along the coast. Azores. The limit of distribution seems to be at the subarctic and subtropics. It is not reaching into arctic Scandinavia and only along the coast does it go as far north as 64°. Although included in the subarctic region Iceland has a temperate climate. In Asia it reaches only the border of the subarctic region as well as in Canada. Nowhere is it present in a subtropical climate. The equatorialward limit being at 20° N or S. Original home is probably to be found in eastern Europe or adjacent parts of Asia south of the greatest extension of the glaciers in the last Ice age. It is certainly wrong to call a species world-wide when it is absent from Arctic, subarctic, subtropical and tropical regions of the world and still this is quite a common practice in recent publications. Discussion of the different morphs described (Table 13): Only those forms not synonymized by MICHAELSEN (1900) will be treated here.

1. *Enterion roseum* SAVIGNY 1826. Defined by SAVIGNY as follow: Setae closely paired. Clitellum on xxv—xxxii. Tubercula pubertatis bipartite on xxix and xxx. Quadrithecal, spermathecae situated near mD. Octovesiculate. TÉTRY (1937) reexamined the types and made the following additions. Number of segments 116, 130. Length 28, 35 mm. Clitellum on xxv, xxvi—xxxii. Tubercula pubertatis as single bands on xxix—xxxi.

2. *Allolobophora rosea macedonica* ROSA 1893. Only difference from typica is genital markings of a, b over the clitellar segments. Later authors have regarded worms with genital papilla on preclitellar segments as intermediate between typica and *macedonica*. Addition of a few extra genital markings can, however, not be regarded as of any taxonomic importance. *Macedonica* is known from England, Switzerland, Austria, Yougoslavia, Manchukuo. U.S.A. and South Africa.

3. *Eisenia rosea* f. *bimastoides* COGNETTI 1901. This form differs from typica in being athecal and quadrivesiculate. All intermediate thecal and vesiculate forms have now been found. This is just one stage in the parthenogenetic reduction of the genital organs and of no taxonomic or zoogeographical value. COGNETTI DE MARTIIS (1902) describes a worm under the name *Eisenia rosea* from Argentina but which is indistinguishable from *bimastoidea*. MICHAELSEN (1903a) transferred *bimastoides* to *Bimastus*, this was not upheld by later authors. PLISKO (1965) says that *bimastoides* is distinguished from typica in having the tubercula pubertatis on xxix—xx instead of xxix—xxxi. This cannot be upheld since the types had the tubercula on xxix—xxi. *Bimastoides* has been recorded from Poland, Austria, Bulgaria, France, Italy, Sardinia, Algeria, Egypt, South Africa, Argentina and U.S.A.; from the latter two countries under the name *Eisenia rosea*. In 1952 OMODEO synonymizd formes from Argentina (*E. rosea* of COGNETTI), *E. r.* typica of COGNETTI DE MARTIIS 1905 (part.), *E. r.* typica of ČERNOSVITOV 1940 (partim, from Palestine), *A. rosea* (partim) of OMODEO 1950, 1952 with *E. rosea* f. *acystis* (MICH.) because they were all athecal. It is clear, however, that they

would have to be called *bimastoides* as this name has priority. It is also very likely that *acystis* has nothing to do with *rosea* (see below).

4. *Helodrilus* (*Bimastus*) *indicus* MICHAELSEN 1907. Differs from *bimastoides* only in having the tubercula pubertatis on xxvi—xxx and first dorsal pore in 5/6. The latter character needs no comment. The tubercula are further forward than in any other form of *rosea* but POP (1947b) records the position of the tubercula in Austrian material of typica as being on $^1/_2$xxvii, xxviii, xxix—xxi. Inclusion of xxvi in the range of variation seems feasible although apparently very rare. Abnormalities in the position of the tubercula are also rather common. The type and only locality (Calcutta) is a few thousand kilometres outside the range of endemic lumbricids, so *indicus* must have been imported to Calcutta by man and has to be one of the peregrine species. The only species it can be synonymized with is *rosea* as was done by GATES (1958b). OMODEO (1959) regards *indicus* as related to *Dendrobaena atheca* ČERNOSVITOV 1940 and *D. syriaca* ROSA 1893 and that *indicus* should be placed in *Dendrobaena*.

5. *Helodrilus* (*Allolobophora*) *prashadi* STEPHENSON 1922. Differs from *bimastoides* in being octovesiculate and proepilobic. Several other species are known where the form of the prostomium varies and this character cannot be regarded as of even infraspecific value. In macerated *rosea* the form of the prostomium can vary quite a lot and is just a matter of opinion whether one should consider it proepilobic or epilobic. *Prashadi* has been recorded from Kashmir and adjacent parts of SSR and Bulgaria.

6. *Eisenia rosea* v. *Štorkani* ČERNOSVITOV 1934. Differs from typica in having the first dorsal pore in 6/7, genital markings of a, b on xxiv—xxvi and in the absence of thickened septa. All these differences are of such small quantitative nature that they cannot be considered to be of any taxonomic value. It is probably that it could not be separated from typica if it was found again even by the most ardent splitter since the differences are too small. *Štorkani* is known from Bulgaria.

7. *Allolobophora hataii* KOBAYASHI 1940. Differs from *bimastoides* in being octovesiculate and having a proepilobic prostomium. Only difference from *prashadi* is that this "species" has a few more genital markings (in which it resemble *macedonica*). There is no reason to distinguish it from *rosea*. Known only from the type-locality, Manchukuo.

8. *Allolobophora harbinensis* KOBAYASHI 1940. Differs from *macedonica* in having a proepilobic prostomium. This is of course only an individual variation. Known only from the type-locality, Manchukuo.

9. *Allolobophora dairensis* KOBAYASHI 1940. Only difference from *macedonica* is in the proepilobic prostomium, clitellum on xxiii—xxxiii and being athecal. The extension of the clitellum is the only character that is of any importance but all

intermediates are known between *dairensis* and *rosea*. There is thus no reason to uphold this "species". Furthermore Manchukuo is outside the range of endemic lumbricids.

10. *Allolobophora jeholensis* KOBAYASHI 1940. Differneces from *macedonia* are: Prostomium epilobic or procpilobic, athecal. Jehol is outside the range of endemic lumbricids and differences are only due to individual or parthenogenetic variation. This species is thus synonymized with *rosea*. Only known from the type-locality, Jehol.

11. *Eisenia rosea* v. *balcanica* ČERNOSVITOV 1941. Has the typica arrangement of spermathecae and the *bimastoides* arrangement of seminal vesicles otherwise indistinguishable from typica and is thus synonymized with *rosea*. Only known from Croatia and Macedonia.

12. *Eophila kulagini* MALEVIČ 1949. Quadritheeal and quadrivesiculate, vesicles in xi, xii and is thus intermediate between typica and *bimastoides*. Only known from the type-locality, Kirgistan.

13. *Eisenia rosea* v. *dendrobaenoides* OMODEO 1950. Differs from typica in having the first dorsal pore in 3/4 or 4/5 and being sexvesiculate, vesicles in ix, xi, xii. The position of the first dorsal pore is of no importance and the absence of seminal vesicles in x is due to parthenogenesis. Known from Italy.

14. *Eisenia jenensis* FÜLLER 1952/53. Indistinguishable from typica. FÜLLER states that his "species" should be distinguished from typica in having the tubercula on xxix—xxx but this is often the case in typica as well. Only known from the type-locality, Germany.

15. *Allolobophora rosea lusitana* GRAFF 1957. GRAFF states that this "subspecies" differs from typica in setal arrangement and in the absence of dorsal pores on the clitellum. Further differences are: first dorsal pore in 5/6. Octovesiculate, vesicles small, confined to x (sic). The setal ratios given by him are almost identical with those previously published (Table 14). Dorsal pores, especially in soft or macerated worms, are often invisibly on clitellar segments. There is thus no reason to retain this form. Only known from the type-locality, Portugal.

16. *Allolobophora rosea* f. *interposita* PLISKO 1965. This form was erected on forms with intermediate external character between *bimastoides* (sensu PLISKO) and typica. The only difference noted is that the tubercula end on xxx in *bimastoides* on $^1/_2$xxxi in *interposita* and xxxi in typica. If we recognized such small differences we would have to describe every specimen as a new forma. Only known from Poland.

17. *Allolobophora rosea* f. *alpina* VEDOVINI 1968. Differs from typica in having the spermathecal pores in CD instead of between D and mD and being diploid. It is without doubt a typica. Only known from the type-locality, France. According to the 1961 edition of the International Code of zoological nomenclature no names

described as forma has any nomenclatural standing and this form would then have to be renamed if it turned out to be something else than a synonym to *rosea*.

18. *Eisenia rosea* ?var. ČERNOSVITOV 1940. Described from Jordan. Its only difference from typica is in the absence of spermathecae.

19. *Eisenia rosea* ?var. ČERNOSVITOV 1941. Described from Egypt. Differs from *bimastoides* in being sexvesiculate, vesicles in ix, xi, xii. In this character it is identical with *dendrobaenoides*.

Forms formerly synonymized with *rosea* but here excluded:

1. *Dendrobaena riparia* BRETSCHER 1902. Only difference from typica is in the bipartite condition of the tubercula and in having the seminal vesicles in ix, xi, xii. Synonymized with *rosea* by POP (1947b) and with *Allolobophora* (*Microeophila*) *antipai* MICHAELSEN 1891 by OMODEO (1956a) after re-examination of the type. On the authority of OMODEO and because the bipartite tubercula are regarded as of specific value in the caliginosa complex it is here excluded.

2. *Helodrilus* (*Allolobophora*) *acystis* MICHAELSEN 1902. Differs from typica in being athecal and lacking a calciferous sac in x. It was synonymized by with *rosea* by POP (1947a) and OMODEO (1952b). PEREL (1967) regards *acystis* as a synonym of *Eisenia nordenskioldi* (EISEN) 1879. GATES (1969) regards the origin of the calciferous glands (sacs) to be of generic importance. It is thus excluded from *rosea*.

3. *Eisenia rosea* v. *croatica* SZÜTZ 1909. Differs from typica in having a clitellum on xxiv—xxxiii and tubercula pubertatis on $^1/_2$xxix—$^1/_2$xxxiii according to SZÜTZ. I can find no mention of pigmentation in the Hungarian text, neither in the German summary nor in his 1919 paper where the variety is raised to specific status. POP (1943) synonymized this variety with *Eisenia submontana* (VEJDOVSKY) 1875 now *E. lucens* (WAGA) 1857. This would imply that the worms were pigmented. It is thus tentatively removed from *rosea*.

4. *Eisenia rosea* v. *budensis* SZÜTZ 1909. This form differs from typica in having a tanylobic prostomium. I can find no mention of whether this form was pigmented or not. Although POP (1968) recorded *bimastoides* with a tanylobic prostomium *budensis* is tentatively excluded from *rosea*.

5. *Dendrobaena diomedea* COGNETTI DE MARTIIS, 1906. Differs from typica as follows: Pigmented red. Tubercula pubertatis tripartite on xxix—xxxi. It was synonymized with *rosea* by POP (1947b) and KARAMAN (1969) and regarded as a distinct variety of *Eiseniona handlirschi* (ROSA) 1897 by OMODEO (1956a). Any worms with the red pigment so characteristic of *Dendrobaena* would have to be excluded from *rosea* regardless of other characters. KARAMAN (in litt., 1969) informs me that his *diomedea* are unpigmented so they have been synonymized with rosea.

Evolution of morphs: All records of *rosea* are referable to parthenogenetic strains with the possibly exception of the find from the Basses-Alpes (VEDOVINI 1968). This form is diploid and with a full complement of spermathecae and seminal vesicles. In the following I will discuss the evolution of the different morphs which can be derived from a (hypothetical) biparental *rosea*. This biparental morph probably was quadrithecal, octovesiculate (vesicles in ix—xii) and with tubercula pubertatis on xxix—xxxi. It is less certain that it possessed genital markings on anteclitellar and clitellar segments, the latter then only involving a, b, but the frequency with which genital markings have been found in specimens closely related with a biparental morphs makes it likely. This ancestor is very close to the morph described by VEDOVINI. The following nomenclature will be used for the different morphs. T refers to the spermathecae, SV to seminal vesicles, index figures to the number of spermathecae and seminal vesicles. T_0 and SV_0 means athecal and avesiculate respectively.

When the absence or presence of genital markings are included twenty combinations (Table 15) or strains of *rosea* have been found. If only the combinations of T and SV are counted they are ten. There seems to be no correlation between the number of T and ploidy and only a weak one between T and SV or T and GM. The reduction of T, SV and GM seems to be independent of each other. Among the T_4 the number of SV are between two and eight and among the T_0 there exist SV_4—SV_8. The most frequent reduction is from T_4 to T_0. T_2 have only been found twice (South Africa and Afghanistan) and T_1 only once (Afghanistan). Vestigial Ts have been reported from Germany (BALTZER 1956) and Austria (POP 1947). SV_8 is the most frequent morph followed by SV_4, SV_6 and SV_5. Among the SV_4 it is always the anterior pairs (in ix, x) that are absent, among the SV_6 those in ix are absent in three cases and those in x in 9 cases. In the only SV_5 known the vesicles are present in x right, xi, xii. Thus the first vesicles to go are the two pairs in ix, x followed by the pair in x and lastly by the pair in ix. GRAFF's (1957) statement that there should be four pairs of small vesicles in x needs confirmation and must for the time being be considered an abnormality. However, shift in the segmental position of organs have been reported for some tropical earthworms, it is especially frequent in *Perionyx* after regeneration.

It is clear that the reductions of Ts and SVs is very abrupt (Fig. 5) and involves one or more pairs at a time. Gradual reductions have been so rare that it cannot be considered to be important in the evolution of parthenogenetic morphs. It seems also likely that the different numbers of SVs have evolved independently from each other in different parts of the world and at different times in the same population. Consequently, a SV_4-morph from South Africa is only related to other SV_4 form the same locality and from the parent SV_8, it cannot in any way be related to SV_4 in other parts of the world or to those from other populations in South Africa. SV_0 has not yet been found but it can be expected.

The presence of genital markings on clitellar segments was correlated with the loss of one chromosome (from 54 to 53) by Muldal (1952). Presence of genital markings on these segments have been found in all but one case to be in T_4SV_8-morphs. the exception is a T_0SV_8-morph. The genital markings are first lost on the clitellar segments and then on the region of the male and finally at the region of viii—xiii. The genital markings have usually been considered to have some reproductive function but what is unknown. Pickford (1926) believed that they helped the worms to stay together during copulation and said that they were more frequent in larger than in smaller worms.

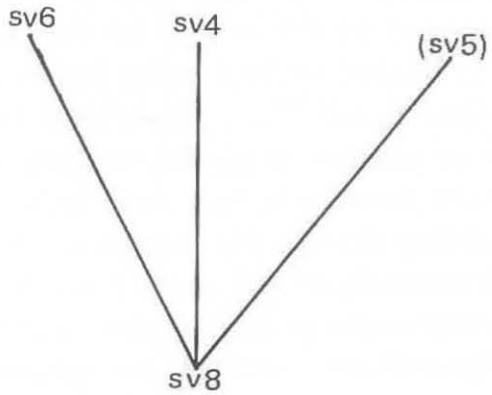

Fig. 5. Dendrogram showing the mode of reduction of the seminal vesicles in *Eisenia rosea*.

In parthenogenetic worms there is of course no need for genital markings tubercula pubertatis, spermathecae, seminal vesicles, testes with their funnels and testis-sacs and these organs are consequently gotten rid of. In lumbricids this reduction does not seem to have gone so far as in certain Pheretimas.

Generic relation: This species is usually placed either in *Eisenia* or in *Allolobophora*. But it cannot go into *Eisenia* as this genus has no calciferous sac in x by definition (Omodeo 1956a: Gates 1969). Gates (e.g. 1969) has said that *rosea* cannot go into *Allolobophora* as this genus has *chlorotica* as its type. This species was designated the type by Omodeo (1956a) but it shows so many pecularities that it would exclude most other species from the genus which now are included, according to Gates. It is also impossible to place *rosea* in any of the other lumbricid genera as currently defined. It is thus left in *Eisenia* till the position becomes less confused. It will probably be impossible to speak about generic relationships of most species till a revision of the whole family, considering the somatic anatomy, has been done.

Diagnosis: The only diagnosis which at the moment can be given is: prostomium epilobic, unpigmented, setae closely paired, calciferous sac in x. This will exclude some of the most similar (but not related) species but is still so vague as being almost meaningless.

2.3.9. *Eiseniella tetraedra* (Sav.) 1826
(5 specimens from 4 localities)

Allurus tetraedrus, Michaelsen 1899a: 97
Helodrilus (Eiseniella) tetraedrus f. *typica* & f. *bernensis*. Michaelsen 1913b: 60—61, 1913c: 551 (typica only)
Eiseniella tetraedra, Pickford 1937: 37
Eiseniella tetraedra tetraedra. Jamieson 1967: 70—74, f. 3: A—C, Table 5

Previous records: Cape Province, Port Elizabeth (Michaelsen 1899a); Knysna, main forest (Michaelsen 1913c); Cape Flats (Pickford 1937); Krom River, just N of Stellenbosch, French Hoek stream, bridge at La Motte, Wemmers River (Jamieson 1967).
Transvaal, Pretoria, Zoological Gardens at Aapies River (Michaelsen 1913b); Jukskei River near Bryanstown, Johannesburg (Jamieson 1967).
New records:

N 30, Ixopo distr., Ixopo at the road bridge over Ixopo River, Grass field with brown, clayey soil. Worms in 0—2 cm layer among the roots. 15. v. 67. POL. 0-0-2

N 40, Howick, af toot of Umgeni Falls. Grass, some trees and bushes. 16. x. 67. AJR & POL. 0-0-1

T 3, Potchefstroom, Rhodes plot. In old fruit garden and in a cemented ditch. 12. ix. 67. POL 0-0-1 (probably from ditch).

T 8, Potchefstroom, in artificial river for experiments with snails. Very foul water, most of the "river" filled with algae and all snails present were dead. 0-0-1

Distribution: In ditches, streams and rivers from K, E and Sn regions. First collected in around 1898. Original home Europe or adjacent parts of Asia.
Remarks: All specimens seen were of a morph with the male on xiii. The specimen from T3 had an annular clitellum on xxiii—xxvi. Tubercula pubertatis as equally broad bands just above B on xxiii—xxv. Spermathecal pores in 8/9, 10/11 at $^1/_2$BC. The spermathecae were in ix, x right. The "forma *bernensis*" is a morph with the male pores on xii.

2.3.10. *Lumbricus rubellus* Hoffm. 1843

Lumbricus rubellus, Michaelsen 1908: 42, 1913c: 551
Previous records: Cape Province, Cape Flats (Michaelsen 1908, repeated in Michaelsen 1913c).

Distribution: The only known locality is in the A region. First and only find from 1904. Original home Europe or adjacent parts of Asia.

Remarks: Pickford (1937) mentioned the presence of *Lumbricus* sp. in a few places in the Cape Province. *L. castaneus* can be expected when more thorough collections are made around Cape Town.

2.3.11. *Octolasion tyrtaeum* (Sav.) 1826
(2 specimens from 1 locality)

New records: Cape Province, Cape Town. 17. i. 1872. G. de Vylder. Det. E. Perrier as *O. lacteum*. 1-0-0 (RM No. 91).
T 29, Potchefstroom, in a plant pot. December 1967. V. A. Attwell. 1-0-1

External: Length of adult 93+ mm (amputee, only tip of tail lacking). Number of segments 95 + (adult), 115 (juvenile of 15 by 1 mm). Prostomium epilobic about $^1/_2$, tongue open. First dorsal pore in 9/10.

Clitellum saddle-shaped, extending down to below A on xxx—xxxv. Tubercula pubertatis on xxxi—xxxv. Glands associated with the male pores extending slightly on to xiv and xvi.

Internal: Seminal vesicles increasing in size posteriad, in ix—xii. Spermathecae in x, xi round, somewhat dorso-ventrally flattened and empty. Tubercula pubertatis glands not seen and probably absent.

Distribution: Only known from Cape Town (garden?) and Potchefstroom in M and Sn regions. First collected in 1872. Original home Europe or adjacent parts of Asia.

Remarks: The adult worm from T29 could not have been longer than about 100 mm. The Cape Town specimen determined as *lacteum* had not developed any external sign of maturity and was un-dissected. Possibly there was originally more than one specimen. Dissection of this specimen confirmed it to be an *Octolasion* (seminal vesicles in ix—xii, testes and their funnels enclosed in testis-sacs). The setae are closely paired throughout the length of the worm which favour identification with *tyrtaeum*. This species was formerly known as *O. lacteum* (ÖRLEY) 1885, It might be conspecific with *O. cyaneum* (SAVIGNY) 1826 and the latter will probably also be found in the Cape Province.

2.4. Megascolecidae

This family has endemic genera and species in tropical Asia from India to China, Japan, Indonesia, the Phillipines, Australia, Melanesia, probably Polynesia and Micronesia, and the Pacific coastal strip of U.S.A.

Peregrine species are found in *Lampito*, *Perionyx* and *Pheretima*. The last mentioned genus is the biggest in the Oligochaeta with around 300 species of which about 30 are peregrine. Representatives of the three peregrine genera have found their way into most parts of the tropics and subtropics and with some intrusion into temperate regions by Pheretimas. The latter genus has been found in greenhouses as far north as Norway (STOP-BOWITZ, personal communication, 1969). So far six peregrine species of *Pheretima* have been found in South Africa. Absence of *Perionyx* spp. and *Lampito mauritii* is surprising.

2.4.1. *Pheretima californica* KINBERG 1866

Pheretima californica, GATES 1954: 226

2.4.2. *Pheretima diffringens* (BAIRD) 1869 (Fig. 6—7, Table 16—17)

(285 specimens from 35 localities)

Pheretima heterochaeta, MICHAELSEN 1913a: 147, 1913e: 417
Pheretima (Pheretima) indica ssp. typica, UDE 1932: 146—147
Pheretima diffringens, GATES 1954: 227—228

Previous records: Cape Province, Port Elizabeth (Ude 1932); Kirstenbosch (Gates 1954); E. Transvaal, Wateral Baven, Natal, Durban; Dorp Spruit and Scottsville, Pietermaritzburg; Zwaartkop Valley near Pietermaritzburg; Howick, Hilton Road (Michaelsen 1913e).
Transvaal, Pretoria, Zoological Gardens (Michaelsen 1913a).
New records:

C 7, At a high-school about 1 mile from Kokstad on the Matatiele rd. At poutlet of polluted water in a grass field. Soil black 3 upper cm, then brownish. 18. x. 67. POL & AJR. 0-3-13

C 14, 7.6 miles form MacClear on the Ugie rd besides motor bridge near small stream. Very sandy soil with clay beneath. 19. x. 67. POL & AJR. 3-4-46

C 17, 24 miles from Umtata on the Port St. Johns rd. Grass field close to subterranean stream. Dark brown to black soil. 20. x. 67. POL & AJR. 0-1-9

C 19, Port St. Johns distr., 57 miles from Umtata on the Port St. Johns rd. In a deciduous forest with ferns and elephant-grass. Rich soil. 20. x. 67. POL & AJR. 0-0-1

C 22, 24 miles from Port St. Johns on the Lusikisiki rd. 20. x. 67. POL & AJR. 0-0-1

C 23, 1.1 miles from Port St. Johns on the Lusikisiki rd. In very wet soil. 20. x. 67. POL & AJR. 0-0-1

C 26, 28 miles from Lusikisiki ob the Tabankulu rd at border of Flagstaff/Lusikisiki distr. At bridge over River Mzimalava (= Ludeka loc. No. 2). Very rich, black soil at margin of the river. 1-0-1

C 44, King William's Town distr., 26.6 miles from Kidd's Beach on the King William's Town rd. Sandy, brownish, dry, soil. 26. x. 67. POL & AJR. 0-0-1

N 1, Zululand, Eshowe municipal dam (at Umlalazi River). Very rich, black soil. In garden and along bank (among reeds). 8. v. 67. POL. 0-0-2

N 2, Zululand, Qudeni forest. Nov. 1965. W. J. Lawson. 0-0-3 (in DM)

N 12, Inanda distr., about 3 miles from Mt. Edgecombe on the Umgeni rd. In sugar cane field. 10. v. 67. POL. 0-0-3

N 19, Port Shepstone distr., at Ntshambili river 2 miles SW of Umzumbe. Black, fertile soil. 0-0-1

N 25, Umzinto distr., at Amahlongwana river on the Umkomaas-Umzinto rd. In a grass field with clayey, very wet soil. 13. v. 67. POL. 0-0-1

N 30, Ixopo distr., Ixopo at road-bridge over Ixopo river. Grass field with brown, clayey soil. Worms 0-2 cm among roots. 15. v. 67. POL. 6-4-26

N 32, Ixopo distr., Esperanzo 1938, 1 mile W of Highflats on the Umzinto-Ixopo rd. At edge of grass field with dark, greyish-brown, wet soil. 16. v. 67. POL. 0-0-2

N 34, Ixopo distr., Highflats on St. Faith's rd. At a dam about 300 m to the left of the rd. In grass field with dark, very wet and fertile soil. About 1 m² searched. 16. v. 67. POL. 0-0-2

N 36, Ixopo distr., 9.3 miles from Highflats on the Hlokozi rd. In grass field on marshy bog. Very black, rather wet soil. 17. v. 67. POL. 0-0-6

N 37, Paul Pietersburg distr., at Pongola river about 17 miles from Paul Pietersburg, In grass field (*Themedia*) with very clayey soil. 18. vii. 67. POL. 0-0-2

N 40, Howick Falls, at foot of the falls. Grass, some trees and bushes. 16. x. 67. AJR & POL. 1-0-7

N 42, On the Port Shepstone-Margate rd at a stream. 17. x. 67. AJR & POL

N 44, On the Umfolozi-Port Edward rd. 17. x. 67. AJR & POL. 0-0-1

T 12, Pietersburg, Boomstraat 99. In a garden. 10. vii. 67. AJR. 0-0-2

T 13, Magoeba's Kloof distr., Woodbush reserve on the Houtboschdorp rd about 6 miles from Houtboschdorp. Lateritic soil. 8. vii. 67. AJR. 38-0-4

T 15, Pietersburg distr., at the outflow of the Ebeneser dam. Rocky, lateritic soil. 8. vii. 67. AJR. 3-2-10

T 17, Magoeba's Kloof distr., about 8 miles from Ebeneser dam on the Magoeba's Kloof rd. Lateritic soil. 8. vii. 67. AJR. 3-5-7
T 18, Magoeba's Kloof distr., Woodbush reserve about 3 miles from Magoeba's Kloof. 8. vii. 67. AJR. 0-0-3
T 19, Tzaneen distr., about 20 miles from Tzaneen on the Strydon tunnel rd near motor bridge. 9. vii. 67. AJR. 0-0-16
T 20, Tzaneen distr., at bank of Letaba river $^1/_2$ mile from Tzaneen on the Phalaborwa rd. 8. vii. 67. AJR. 0-0-19
T 21, Piet Retief distr., Paul Pietersburg-Klipwal rd at tributary to Pongola river WSW of Confidence & ESE of Wetteran 176. 19. vii. 67. POL. 0-1-6
T 25, Roodeport, 158, 6th Ave. In humus-heap in a garden. 4. xi. 67. B. J. J. Haasbroek. 0-0-1
T 28, Loskop dam. Grass, rich, organic soil. 3. x. 67. J. Matthew. 0-0-4
T 33, Middelburg distr. (rest illegibly) + (another batch) M. Pistorius iii. 68. (date for both batches). 1-0-2
T 34, Middelburg. 18. iii. 68. A. Britz. 0-0-2
T 35, Middelburg, on the bank of Vaal river. iii. 68. A. Wilken. 0-0-1
T 36, Nelspruit, at the river bank. AJR. iv. 68. 0-0-3

Malawi

Blantyre, small stream at Limbe rd. 29. vi. 68. POL.

External: Length, usually 49—95 mm. An unusually big worm from T1 was 224 mm. Width 3—4 mm. Pigmented light reddish brown to dark brown. Number of segments (40) 80—115, mean 101.975. 90% of the worms had 86—111 segments. Prostomium epilobous (all). Setae present on ii but are rather small. Setae of iii—ix increasing slightly in size, but the increase is not as pronounced as in *P. hawayana*. They are absent on the clitellum in adult worms but sometimes present ventrally on xiv—xvi or part of these segments in aclitellates. Numbers (Table 16—17) 17—29/ii, 24—31/iii, 24—33/v, 37—48/ix, 48—73/xx, v/6—10, vi/8—11, vii/7—13, viii/10—16, xviii/8 (1), 9 (1), 10 (7), 11 (20), 12 (28), 13 (20), 14 (10), 15 (1), mean of 88 12.023, 90% of the worms had 10—14 setae between the male pores. 8 and 9 setae (each occurring only once) is probably due to fall out of setae.

Table 16 Number of setae in different segments in *Pherelima diffringens*

	ii	iii	v	ix	xx
	21	24	26	37	48
	26	24	27	39	48
	27	27	30	40	55
	27	31	32	47	56
	29	31			56
					60
	17	28	24	48	73
	21	29	33	48	54
Range:	17—29	24—31	24—33	37—48	48—73

Table 17 Number of setae between spermathecal pores in *Pheretima diffringens*

	v	vi	vii	viii
	8	8	9	16
	10	9	10	11
	10	9	9	12
	7	9	10	13
	8	9	11	13
	8	10	13	15
	9	11		
	9			
	6	9	7	10
			10	15
Range:	6—10	8—11	7—13	10—16

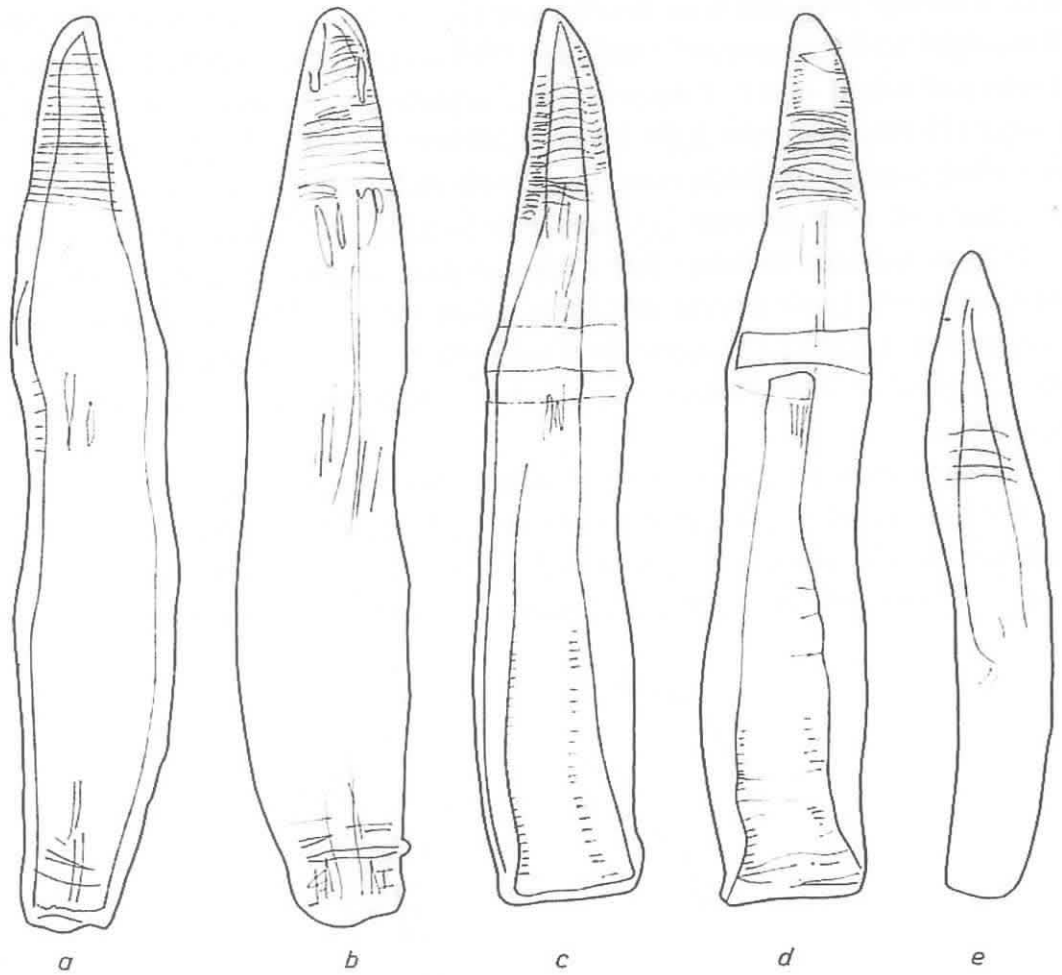

Fig. 6. Setae of *Pheretima diffringens* drawn to same scale from a specimen from N30. a) seta a of iii left, b) seta a of iii right, c) ventrolateral seta of vii, d) ventrolateral seta of viii, e) ventrolateral seta from hind-body.

The setae (Fig. 6) are very thick and robust with a little-developed node situated slightly closer to the ectal than the ental end. They are almost straight and smooth except for transverse grooves on the ectal quarter. The central lumen has the same shape as the setae and extends to the tip. The setae are of the same shape throughout the length of the worm. First dorsal pore in 10/11 (2), 11/12 (45) and ?12/13 (4).

Clitellum annular on xiv—xvi ending exactly at 13/14 and 16/17. Spermathecal pores superficial, minute, four pairs in 5/6—8/9 below mL. Female pore single, minute on eq/xiv at *m*V. Male pores, minute on big, conical porophores on xviii. Genital markings small, disc-shaped, usually paired, ventral, presetal on vii—ix or more rarely vi—ix, usually one or more pairs lacking. Records were kept on the pattern of these markings for about a hundred worms but almost as many patterns as worms investigated was found. The genital markings are easily over-looked and can only be seen when viewed from the side. In some worms small disc-shaped, paired markings were seen just ventral and posterior to the spermathecal pores.

Internal: Pigment very dense in circular muscle layer. Septa 8/9 and 9/10 absent (2) or 9/9 vestigial and only present ventrally, 9/10 lacking (1). Gizzard barrel-shaped in viii. Intestinal origin in xv. Caecae simple, originating in xxvi (1) or xxvi left and xxvii right (1) reaching into xxiv when extending forward. Typhlosole single, mV, straight, thickened at intersegments. Typhlosole ending in lxv in one worm of 105 segments. Hearts of x left present (1). Last pair in xiii. Brain (Fig. 7) crescent-shaped, thick, without isthmus or lobes but with one pair of peristomials and circumoesophageals. Between these nerves are three other nerves. The splitting off of these nerves does not occur at the same level on both sides but is closer to the brain on the left side (and of independent origin) while originating from the peristomials on the right side.

Testis enclosed in testis-sacs in x, xi. Testis-sacs U-shaped and unpaired. Seminal vesicles big (South Africa) to vestigial (Malawi) in xi, xii. Male ducts (in xviii) U-shaped, but S-shaped in the aprostate specimen from T1. Prostates vestigial or absent on both sides (T1) or left side (N3). Spermathecae with a single diverticulum that is

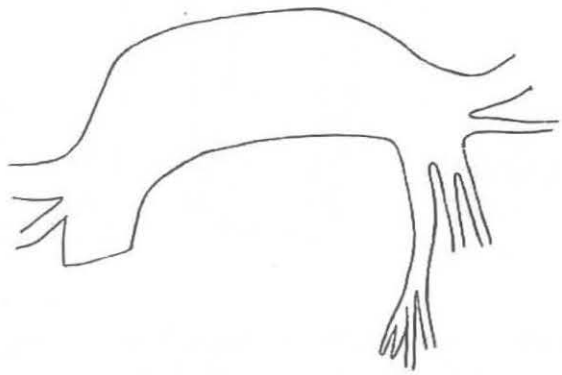

Fig. 7. Brain of *Pheretima diffrigens* from T 26.

slightly longer than the duct, duct rather thick and shorter than the ampulla, ampulla slightly triangular with a broad ental portion. The spermathecae become increasingly bigger and more compressed backwards.

Abnormalities: Clitellum in one specimen only complete on xiv and xv and then developed on the left side on xii and xiii and on the right side of xvi and xvii.

Reproduction: Spermathecae usually empty, but sometimes the ampulla was filled with some white coagulum. No iridescence of male funnels or spermathecae and reduction of the prostates show that the South African worms, like all other investigated, are parthenogenetic.

Regeneration: 50% of the worms from N30 and tail-regenerates, specimens from other localities were often seen with tail-regenerates. In many additional specimens the last two to five segments were asetal (anus terminal). It is not known if this is a sign of regeneration.

Ecology: *P. diffringens* is a top-soil species, always found in the upper layer of the soil. It is most abundant in sugar cane fields, especially in areas where the reeds have been left over the soil to rot. It is then found among the rotting reeds or between these and the soil. It has also been found under grass-cover and is the first species found in lateritic soil. It is possibly a selective feeder since so high a percentage of its gut content was pieces of reed and other organic matter. Worms from T15 contained much debris and very little soil while *P. rodericensis* collected in the same type of habitat had only laterite in its gut.

Distribution: This is the most abundant species in SE, E, L and Nt region, records from garden also include Sn. Original home unknown but possibly in China.

Remarks: *P. diffringens*, *P. hawayana*, *P. morrisi* and *P. rodericensis* are a closely related group, possibly forming a super-species. They have been separated on the number of spermathecae and on genital markings. In the present investigation differences in the number of setae between the male pores were also found: 8—15, mean 12.023 in *diffringens*, 12—16, mean 13.375 in *morrisi*, 14—19, mean 17.122 in *rodericensis*, too little data are available for *hawayana* for a comparison to be made.

2.4.3. *Pheretima hawayana* (Rosa) 1891
(12 specimens from 6 localities)

New records:

N 6, Lower Tugela distr., near Zinkwaxi (43 2016) station on the Stanger-(Tugela) Gingingdlovu-rd. Very dark and wet agricultural soil. 9. v. 67. POL. 0-0-2

N 12, Inanda distr., about 3 miles from Mt. Edgecombe on the Umgeni rd. In sugar cane field. 10. v. 67. POL. 0-0-2

T 28, Loskop dam. Rich organic soil with grass-cover. 3. x. 67. J. Matthew. 0-0-1

?T 29, Potchefstroom, in a plant pot. Dec. 1967. V. Attwell. 1-1-0

T 31, Middelburg distr., Krugersdam. 12. iii. 68. A. v. d. Berg. 0-0-2

T 32, Middelburg distr., Keerom. March 68. G. Hattingh. 0-0-2

External: Length 110 mm. Width 4 mm. Number of segments 96, 98. Prostomium epilobous. Setae present ventrally on xiv and xvi; v/6, vi/5, xviii/12, 17. Setae slightly bigger on ii—iv and vii—ix. First dorsal pore in 10/11.

Clitellum annular on 1/n xiv—1/n xvi. Spermathecal pores three pairs in 5/6 to 7/8. Genital markings three or four pairs postsetal on xviii forming a semicircle between the male porophores.

Internal: Septa 6/7, 7/8, 10/11, 11/12 thickened, 8/9, 9/10 absent. Intestinal origin in xv. Caecae simple, originating in xxvi. Subneural vessel present anterior to iii.

Testes and their funnels enclosed in sacs in x, xi. Seminal vesicles in xi, xii. Male duct J-shaped. Prostatic glands racemose, big, occupying xvi—xxiii or xxiv. Three pairs of coelomic GM glands in xviii. Spermathecae, ampulla almost round, diverticulum moniliform.

Distribution: If T29 is excluded this species is confined to E and Nt region. First collected in 1967. Original home unknown but possibly China.

2.4.4. *Pheretima minima* (HORST) 1893 (Fig. 8—10)
(98 specimens from 4 localities)

New records:

N 1, Zululand, Eshowe municipal dam at Umlalazi river. Very rich, black soil with grass-cover. In a garden. 8. v. 67. POL. 0-4-51

N 18, Port Shepstone distr., Farm Louisiana 3289. Sugar cane field. 11. v. 67. POL. 0-0-3

N 19, Port Shepstone distr., Umzumbe, Ntshambili river 2 miles SW of Umzumbe. Black fertile soil. 11. v. 67. POL. 0-0-3

N 40, Howick falls, at foot of falls. Some trees and bushes. 16. x. 67. AJR & POL. 0-3-32

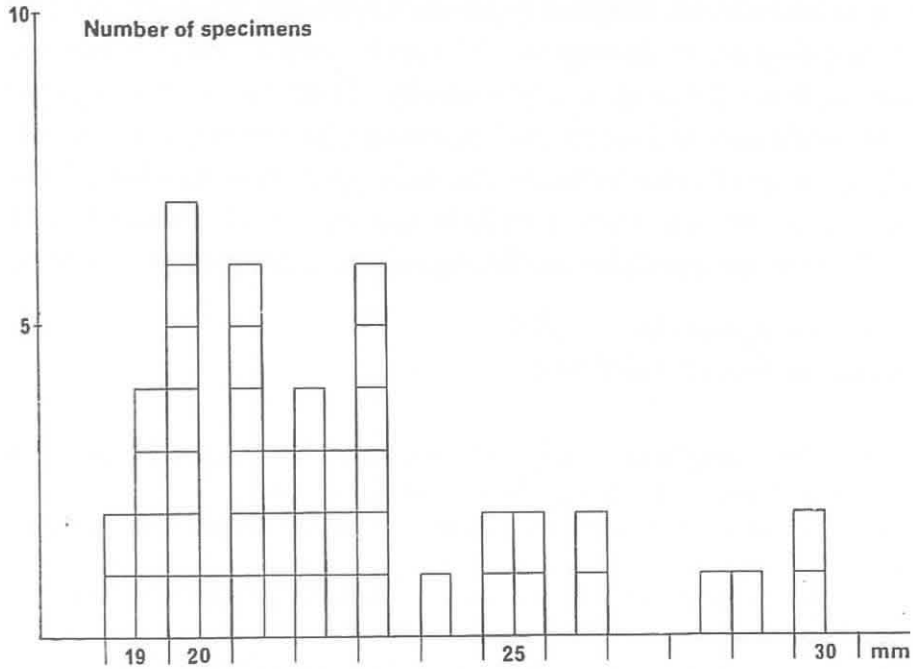

Fig. 8. Length of 47 specimens of *Pheretima minima*.

External: Length (47) (Fig. 8) 19—30 mm, mean 22.245 mm. Width (43) 1—2 mm, mean 1.316 mm. Colour unpigmented white. Number of segments (59) (Fig. 9) 72 to 89, mean 81.983. Those figures that are under 81 can be suspected to be due to amputations, 60 % of the worms had 81—89 segments which probably better shows the range of adult, un-amputated specimens. Prostomium epilobous (all). Setae small and of equal size on all segments, no breaks anywhere. They are present ventrally on xvi (2), 44/ii, 49/iii, 74/x, 74/xx, xviii/4 (2), 5 (5), 6 (23), 7 (26), 8 (19) and 9 (5), range 4—9, mean 7.025 (Fig. 10). First dorsal pore in 11/12, 12/13 (12) and 13/14.

Clitellum annular on xiv—xvi ending exactly at 13/14 and 16/17. Spermathecal pores absent. Female pore minute, single, mV on eq/xiv. Male pores minute on small disc-shaped porophores. Genital markings absent.

Internal: Septa 5/6—7/8 and 10/11, 11/12 thickened, 8/9, 9/10 absent. Gizzard in viii, forepart conical, hindpart of equal diameter. Intestinal origin in xv. Caecae simple, originating in xxii (5), xxiii (8), xxiv (5) and xxv (3). Typhlosole ending abruptly in

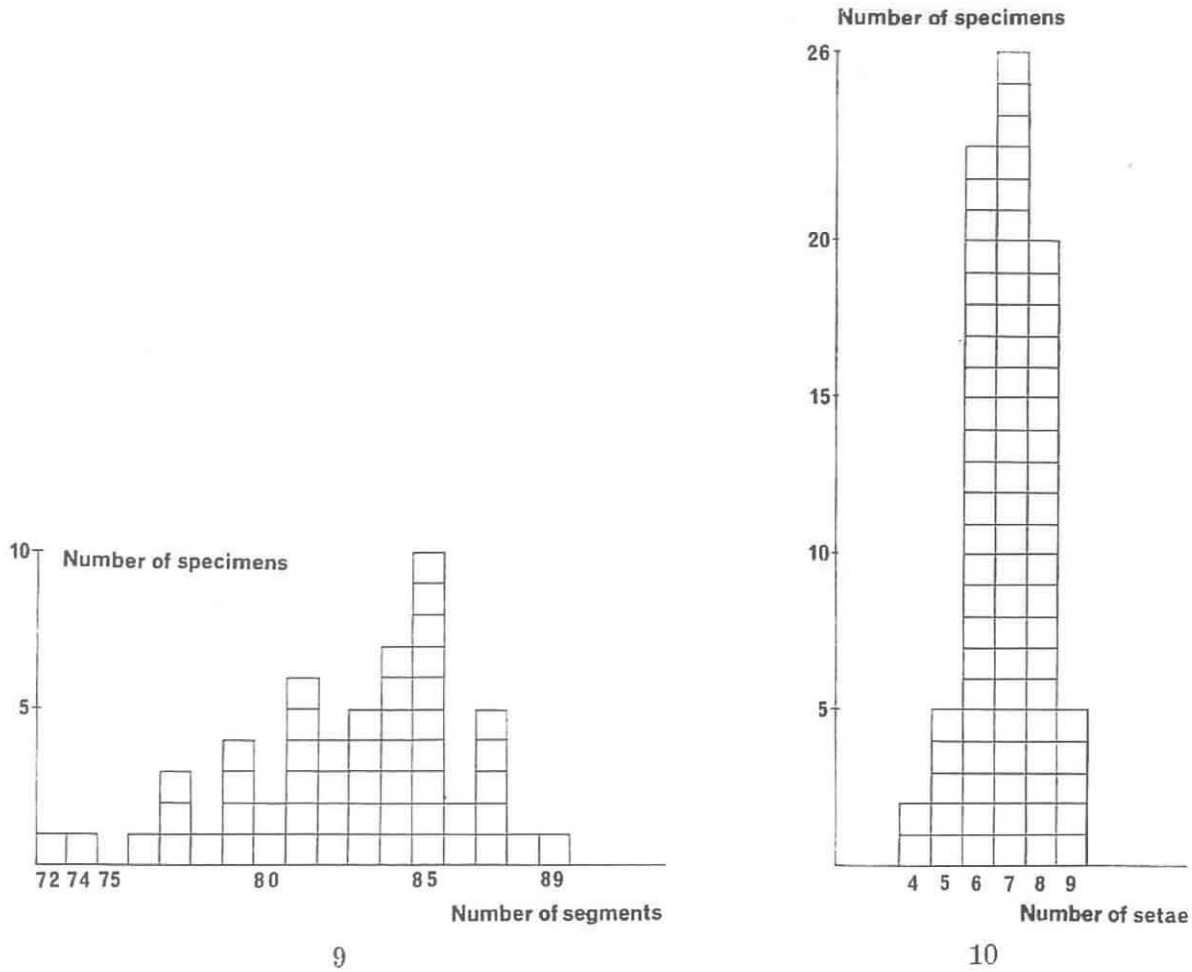

Fig. 9. Number of segments in 54 specimens of *Pheretima minima*.

Fig. 10. Number of setae between the male pores in 80 specimens of *Pheretima minima*.

lix in a worm with 86 segments, leaving 27 posterior atyphlosolate segments. Hearts in x—xiii (2).

Testes and funnels enclosed in unpaired testis-sacs in x, xi. Testis-sacs and funnels (testes not seen) absent (1). Male duct somewhat V-shaped. Ovaries fan-shaped in xiii. Ovisac present. Seminal vesicles absent (5) or present in xii as very small out-growth from 11/12. Prostates big, extending over xvii—xix or xvi—xx. GM glands absent. Spermathecae absent.

Development: The first external sign of maturity is the appearance of the male porophores followed by the glandular development around the female pore and lastly the clitellum. Before the clitellum appears there are complete circles of setae on xiv—xvi.

Abnormalities: 1. Male porophores on xvii left and xviii right (1, N1). 2. Clitellum present on right half of xiii and annular on xiv—xvi, two single, mV female pores on eq/xiii, eq/xiv, male porophores on xvii left, xviii right (1, N1). 3. Clitellum present only on left half of xiv—xvi, male porophores on xvi right and xvii left (1, N40).

Reproduction: As GMs, spermathecae and seminal vesicles are absent in all and testis-sac and male funnels in at least one specimen this species is parthenogenetic in South Africa.

Distribution: Limited to E region. First collected in 1967. Original home possibly in Indonesia.

Remarks: *P. minima* was created on worms from Java. This was the only known locality till 1961 when GATES redescribed it on material from Hawaii and synonymized forms from Burma and Queensland.

GATES' specimens were parthenogenetic but reduction of genital organs had not gone as far in his specimens as in the South Africans worm. Spermathecae were absent in a few cases but GMs were present in all. Except for the above-mentioned reductions the present specimens agree fairly well with those described by GATES. He reported a higher number of setae between the male pores, 6—10 compared to 4—9.

Because of its small size, it is one of the smallest earthworms known, it has probably often been overlooked and it can be expected to turn up in many parts of the tropics and subtropics. This seems to be the first certain record of an unpigmented *Pheretima*.

2.4.5. *Pheretima morrisi* (BEDDARD) 1892 (Table 18)
(12 specimens from 1 locality)

New records:
T 28, Loskop dam. Rich organic soil with grass-cover. 3. x. 67. J. MATTHEW. G-8-4

External: Length (12) 63—107 mm, mean 77 mm. Width (12) 2—3 mm, mean 2.8 mm. Number of segments (12) 73 (amputee), 75 (amputee), 82, 91, 92, 95 (2), 96 (3), 97, range 73—97, mean 89.727. Those figures that are under 91 can be suspected to be due to amputation and subsequent regeneration. Setae present at least ventrally on all clitellar segments (11) and in one aclitellate forming complete setal arcs. Setal numbers v/20, 26, vi/25 (2), xviii/12 (3), 13 (2), 14, 15, 16, mean 13.375. First dorsal pore in 10/11.

Clitellum annular in 1/n—xiv—1/n xvi. Spermathecal pores minute, superficial, two pairs in 5/6, 6/7. Male pores minute on small disc-shaped porophores. Genital markings (Table 18) small, paired disc-shaped on vi—vii (13), small disc-shaped on male porophores two (1) or three (12) on each porophore forming a triangle and in addition one to six presetal markings on xvii (1), xviii (6), xix (7) and xx (1).

Table 18 Genital markings in *Pheretima morrisi*

Segment:	17	18	19	20
Number of GM:		2	2	
		2	2	
		4	6	
			1	
		4	4	
	1	5	1	
		4	4	1

Regeneration: The worms with 73 and 75 segments showed some signs of posterior regeneration, in the one with 75 segments the seven last segments were asetal.

Distribution: Restricted to Nt region. First find in 1967. Original home unknown but is possibly somewhere in China.

2.4.6. *Pheretima rodericensis* (Grube) 1879 (Table 19)
(58 specimens from 9 localities)

Pheretima rodericensis, Gates 1954: 238—239

Previous records: Cape Province, Grahamstown.

New records: South Africa

N 1, Zululand, Eshowe municipal dam at Ulalazi river. Grass on very rich, black soil. In garden and along bank. 8. v. 67. POL. 0-1-5

N 12, Inanda distr., about 3 miles from Mt. Edgecombe on the Umgeni rd. In a sugar cane field. 10. v. 67. POL. 0-0-2

N 13, Inanda distr., Avoca station on a marsh with heavy clayey soil. 10. v. 67. POL. 0-1-0

N 15, Umlazi distr., Amanzimtoti mission reserve. Adam's mission. In an agricultural grass field with blackish soil. 10. v. 67. POL. 0-0-3

N 18, Port Shepstone distr., Farm Louisiana 3289. In a sugar cane field. Wet soil. 11. v. 67. POL. 0-1-23

N 19, Port Shepstone distr., Umzumbe, at Ntshambili river 2 miles SW of Umzumbe. Black fertile soil. 11. v. 67. POL. 0-0-1

N 42, On the Port Shepstone-Margate rd. Along stream 17. x. 67. AJR. & POL. 0-0-4

N 43, Uhlanga river on the Margata-Port Edward's rd. 17. x. 67. AJR. & POL. 0-0-1

T 14, Pietersburg distr., Ebeneser dam the at administration office. Lateritic soil. 8. vii. 67. AJR. 0-0-16

Malawi

Limbe, Limbe stream above Burn's dam. 29. vi. 68. POL. 0-0-14

External: Length 45—145 mm. Width 3—5 mm, usually 5 mm. Colour pigmented very dark brown to blackish, sometimes with a bluish tint at mD. Number of segments (30) 80, 81, 87, 89, 90, 92, 94, 95 (6), 96 (6), 97 (6), 98, 99 (3) and 100, range 80—100, mean 96.566. It is probable that those figures that are under 90 are due to amputation. Prostomium epilobous (all). A complete setal circle present on ii, setae absent on clitellar segments. Setae small on x, xx—xv and big on ix and xi onwards. 20/ii, 21/iii, 28/iv, 22/ix, 26/xi, 46/xx (1). Between the male pores the following numbers were found (49): 14, 15 (3), 16 (10), 17 (17), 18 (7) and 19 (9), range 14—19. mena 17.122. First dorsal pore in ?8/9, 9/10, 11/12 (7) and 12/13 (17).

Clitellum annular on xiv—xvi but not quite reaching 16/17. Spermathecal pores minute, superficial, dorsal, three pairs in 5/6, 6/7 and 7/8. The pores are in the intersegmental furrow but seem to originate from v, vi and vii respectively. Female pore single, minute, mV on eq/xiv. Male pores minute on big round disc-shaped porophores of the same shape as in *P. diffringens*. Genital markings on xviii big round discs, pre- and postsetal lying slightly median to the male porophores. The presetal pair is sometimes intruding slightly on to xvii and may cause the setal arc to form a semi-circle. The following patterns of the genital markings were found (24): Two presetal and two postsetal present (13), (postsetal present) right presetal absent (3), left presetal absent (2), both presetal absent (9), (presetal present) right postsetal absent (2), left postsetal absent (1) and both postsetal absent (7). Thus any one of the markings might be absent but never more than two and if two it is either the presetal or the postsetal pair. One pair was absent in 66 % of the worms while only one marking absent occurred in the others.

Internal: Pigment dense in circular muscle layer. Septa 5/6—7/8 slightly, 10/11—12/13 much thickened, 9/10 absent. Gizzard barren-shaped to almost round in viii. Intestinal origin in xv. Caecae simple, originating in xxvi (2) or xxv (1) and reaching one segment forward. Typhlosole usually triangular and lamelliform. Begins abruptly in xxvii (1) and ends abruptly (Table 19) in lx—lxxiii leaving 17—28 posterior atyphlosolate segments (10). Hearts in x or xi to xiii. Testes and their funnels enclosed in sacs in x, xi. Ovaries in xiii. Seminal vesicles small to very big in xi, xii. Prostatic glands absent (1, N 19) or present (all others) as very long, racemose tubes in xviii

and xix to at the most xvi—xxii. Spermathecae big, stalk almost as long as ampulla. ampulla ovoid, diverticulum almost as long as stalk + ampulla, upper 3/4 moniliform.

Reproduction: No iridescence of funnels or spermathecae, the latter usually empty. Reproduction is probably parthenogenetic.

Parasites: Many white, gregarinid cysts were found in the postclitellar segments in about 50% of the worms from N18.

Distribution: Restricted to E and Nt regions. First collected in 1926. Original home unknown, possibly in China.

Table 19 Ending of typhlosole in *Pheretima rodericensis*

Number of segments	Ending of typhlosole	Atyphlosolate segments
81	64	17
87	60	27
89	69	20
95	67	28
95	68	27
95	69	26
95	71	24
96	69	27
96	73	23
99	63	36
Range: 81—99	60—73	17—36
Mean:	67.300	25.500

2.5. Ocnerodrilidae

This family has endemic representatives in the Americas from Argentine to southern U.S.A. including the Greater Antilles, subsaharan Africa with the possible inclusion of the Seychelles and Madagascar, along the Nile in Egypt and in southern India. Two species are presumably endemic in South Africa (The Free State and Natal).

Most species are amphibious and of minute to small size and one species each of the four genera *Eukerria*, *Gordiodrilus*, *Nematogenia* and *Ocnerodrilus* are peregrine occurring in the tropics, subtropics and penetrating slightly into the warm-temperate regions of all continents and several islands. Several other species can be expected to be exotic in those localities from where they are known. Some species were reported from islands (e.g. Hawaii, the Canaries) in the last decade of the 19th and the first decade of the 20th century but have not been found in much more extensive collections made during the last decade. This seems to be the only cases on record where peregrine species have become extinct in an exotic locality after being introduced there.

Only *Eukerria saltensis* is known from South Africa; absence of *Q. occidentalis* is surprising. ČERNOSVITOV (1940) mentions it from Israel "In Wurzeln von *Litchia sinensis*, aus S. Afrika".

2.5.1. *Eukerria saltensis* Fig. 11)
(167 specimens from 21 localities)

Kerria gunningi MICHAELSEN 1913a: 139 (named only), 1913b (description): 1—3, f. 1, 1913e: 419—420
Kerria saltensis, PICKFORD 1928: 378—379, f. 1—4
Eukerria saltensis, JAMIESON 1967: 61—66, f. 1: A—C, T 2—3

Previous records: Cape Province, Stellenbosch Flats (PICKFORD 1928); Upper Great Berg River at the Driefontein bridge, French Hoek stream at La Motte bridge, Great Berg River at the farm Watergat, at Daljosaphat (near Paarl sewage works), at Lady Loch Bridge at Wellington and at Piquetberg, Krom River near Stellenbosch (JAMIESON 1967).
Natal, Howick at foot of the Umgeni falls, Umgeni near Durban (MICHAELSEN 1913e); Umgababa River, Umbilo River near Durban, Little Bushmans River just above its confluence with the Bushmans River, Tugula River at Hart's Hill (JAMIESON 1967).
Transvaal, Pretoria, Zoological Gardens on bank of the Aapies River (type locality for *K. gunningi*) (MICHAELSEN 1913b).
Transvaal/Orange Free State, Vaal River barrage in Veereniging area, Vaal Dam catchment area, Kalspruit at Grootvlei Coal Mine, Klein Vaal River near its confluence with the Vaal River (JAMIESON 1967).
New Material:

C 7, at a highschool about 1 mile from Kokstad on the Matatiele rd. In a grass field at outlet of polluted water. Soil black 3 upper cm then brownish. 18. x. 67. POL & AJR. 0-0-1
C 13, MacClear distr., about $^1/_2$ mile from McClear on the Ugie rd at a riverbed. 19. x. 67. POL & AJR. 0-0-1
C 26, 28 miles from Lusikisiki on the Tabankulu rd at border of Flagstaff/Lusikisiki distr. At bridge over the Mzimalava river (Ludeka loc. No. 2). Very rich, black soil. 21. x. 67. POL & AJR. 1-0-10
C 28, 13.5 miles from Tabankulu on the Mt. Frere rd. 21. x. 67. POL & AJR. 2-2-5
C 29, Near Copyspruit on the Mt Frere-Umtata rd. In wet, clayey soil at source of small stream. Alt. 3777 ft (ca. 1260 m). 21. x. 67. POL & AJR. 24-0-14
C 35, 19 miles from Engeobo on the Queenstown (= N18) rd. Very wet, hot, clayey, brown soil. At source of subterranean stream. 24. x. 67. POL & AJR. 0-1-1
C 44, King William's Town distr., 26.6 miles from Kidd's Beach on the King William's Town rd. Sandy, brownish, dry soil. 26. x. 67. POL & AJR. 1-0-2
N 1, Zululand, Eshowe municipal dam at Umlalazi river. Very rich, black soil. Found among reeds along the bank. 8. v. 67. POL. 2-0-3
N 6, Lower Tugela distr., near Zinkwazi (43 2016) station on the Stanger-(Tugela) Gingingdlovu rd. Very dark, agricultural soil. 9.v. 67. POL. 0-1-6
N 7, Lower Tugela distr., small stream at entrance to Stanger from Durban rd. In grass field covered with reeds of sugar cane. Very heavy, black, sandy soil. 9. v. 67. POL. 0-0-1
N 9, Lower Tugela distr., Etete river at the old Stanger-Tongaat rd. In grass field with sandy soil. 9. v. 67. POL. 0-0-8
N 10, Lower Tugela distr., dam at Tongaat. Eucalyptus plantation. 0—5 cm black sandy soil on sand. 9. v. 67. POL. 0-3-4

N 12, Inanda distr., about 3 miles from Mt. Edgecombe on the Umgeni rd. A few feet off the edge of a sugar cane field. 10. v. 67. POL. 2-0-0

N 24, Umzinto distr., Glenrosa station (Lot 23), dam SW of mainroad about 7 miles from Umzinto on the Ixopo rd. Black, clayey soil. 12. v. 67. POL. 0-0-17

N 29, Richmond distr., 3 miles S of Umkomaas near small dam on left side of the Richmond-Ixopo rd. Brown, clayey soil. 15. v. 67. POL. 3-5-8

N 33, Ixopo distr., 2 miles from Highflats on the Ixopo rd. In a swampy grass field. 16. v. 67. POL. 0-0-4

N 37, at Pongola river on the Wakkerstroom-Paul Pietersburg rd about 3 miles S of Luneberg. Sand. 18. vii. 67. POL. 0-0-4

N 38, Paul Pietersburg distr., at Pongola river about 17 miles from Paul Pietersburg. 18. vii. 67. POL. 0-0-6

N 40, at foot of the Howick falls. 16. x. 67. AJR & POL. 0-1-22

T 24, Potchefstroom, at the dam below sluice. 7. xi. 67. K. DE KOCK & V. H. ATWELL. 0-0-1

T 27, near Warrington on banks of Vaal river at road-bridge on the Warrington-Kimberly rd. In flooded area. 13. iii. 67. 0-0-1

External: Length (5) 45—85 mm, mean 58 mm. Width 1 mm. Colour pink red in life due to blood-filled capillaries in the body wall, otherwise unpigmented white except clitellum which is yellow or yellowish. Number of segments (6) 102—169, mean 126.333. All anterior segments smooth except xiii whose ventral part is bi-annulated up to about mL (8, C26), posterior segments faintly triannulated. Prostomium epilobic $^1/_2$, tongue open (all). Setae closely paired. Setae b of xviii (both sides) and xix left absent (1), no modified setae. Nephridial pores not seen. Dorsal pores absent.

Clitellum annular, but area between AA less glandular, on xiii—xx (1), $^1/_2$xiii to $^1/_2$xx (1), $^1/_2$xiii—xx (8) or xiv—xx (1) covering 6—7.5 segments. Spermathecal pores minute, two pairs in 7/8, 8/9 in C (T26) or 3/4 BC (N38) or $^1/_2$BC (C26). Female pores paired, minute, slit-like opening on anterior margin of xiv in B. Male pores minute on vxi in seminal groove. Prostatic pores two pairs on xvii, xix just above and in front of b in crater-shaped depression (C26) or on small conical papilla (N38) (Fig. 11a). Seminal grooves bent inwards and surrounded by walls of white, glandular tissue. All specimens without genital markings.

Internal: Pigment absent in either muscle layer. First septum in 5/6, 5/6, 6/7, 7/8 and 8/9 thickened, opaque and conical. Gizzard very poorly developed in vii. Septal glands as white masses that cover dorsum of gut and present posteriad to vi. Calciferous glands paired in ix. Each gland crescent-shaped and united, mesially, by a thick, rather long duct to lateral wall of gut. Intestinal origin apparently in xii (C26) or xiii (T26). Hearts present in x, xi. Nephridia (Fig. 11b) holoic and avesiculate. First nephridium seen in v, in v to xvii they are rather small. From xviii they are very big, filling up most space under the gut and are visible from the outside as white V-shaped patches.

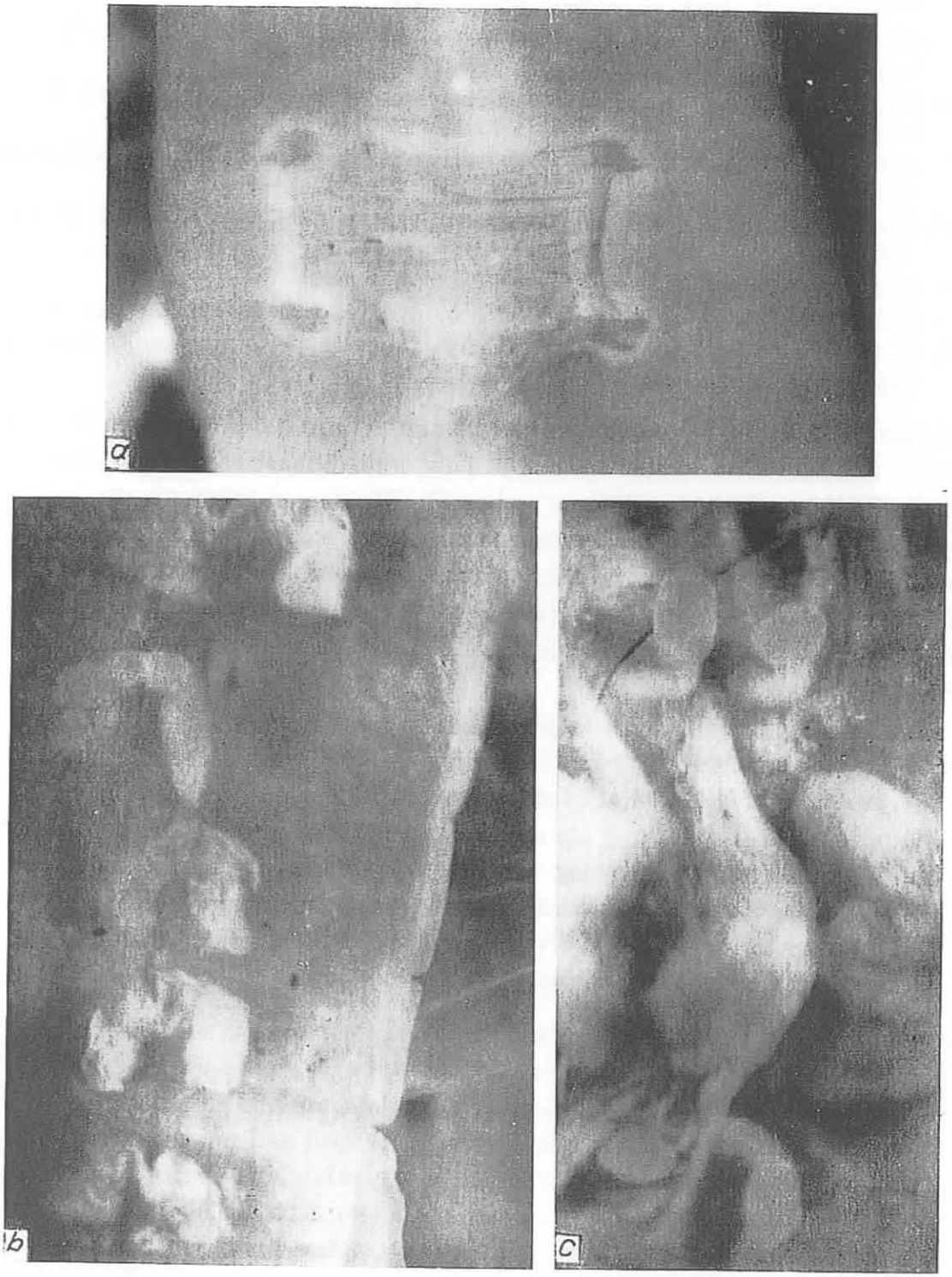

Fig. 11. *Eukerria saltensis* from C26, a) male field; b) Nephridia of left side of xx—xxiv; c) dorsal view of spermathecae and calciferous glands.

Testes and their funnels free in x. Male ducts free in the coelom running to xviii parallel to setae at $^1/_2$BC. Ovaries very big clusters in xiii reaching from floor to roof of gut. Ovisac big and tubular, reaching roof of gut. Seminal vesicles one pair in xi, small, smooth or racemose. Prostates long, tubular, reaching through two segments. Spermathecae (Fig. 11 c) adiverticulate, duct thick and longer than ampulla, ampulla round to oval.

Regeneration: One specimen from C26 had the following characters. Prostomium epilobous $^1/_2$. Clitellum $^1/_2$xi—xviii. Male pores on xvi. Prostatic pores on xv, xvii. 6/7 first septum and thickened. Septal glands to vi. Calciferous glands in vii. Intestinal origin in x. Hearts in viii, ix. Ovaries in xi. Seminal vesicles vestigial in ix. Spermathecae half normal size in vii. Thus all organs have been shifted two segments forward. No external sign of regeneration was found so the level of amputation could not be determined. The only abnormality observed was in the number of spermathecae (two instead of four).

Distribution: *E. saltensis* is one of the commonest earthworms in the SE, E and L regions but has been found only rarely in the Sn region. First collected in 1911.

Remarks: The worms are present in or near the water's edge of rivers, streams and dams. When the soil is saturated and "swampy" they might be found up to a dozen metres from the water's edge. They have been found in brown to black clayey and sandy soils under grass-cover, rarely in sugar cane fields in which case they occur among the reeds. In black, clayey soils they are extremely abundant and must reach populations of several thousands per square metre. They occur only in the 0—5 cm layer. They do apparently not deposit castings on the ground. They must be very tolerant to pollution as they have been found in outlets for industrial and human wastes and are usually the only oligochaete found in streams, rivers or small dams. Occasionally they have been found together with *Branchiura sowerbyi* and *Lumbriculus variegatus*, two other introduced oligochaetes.

There are no differences between *E. saltenis* and *K. gunningi*. *Eukerria saltensis* was divided by GAVRILOV (1952) into f. typica, var. *gatesi* and var. *bellavistensis*. *E. saltensis* f. typica is said to be circummundane, *gatesi* should be confined to Burma and *bellavistensis* to the Tucuman Province. The genus is endemic to South America and all other records are due to transportation by man. It is unlikely that new taxa should have evolved since their introduction but it is possible that earthworms are described from introduced populations before the original home is found.

The morphological differences listed by GAVRILOV are length 25 mm in typica, 27—30 mm in *gatesi* and 35—100 mm in *bellavistensis*. The size of earthworms depends on the availability of nutriments and 35—83 mm was found by JAMIESON (1967) and 45—85 mm in the present investigation which bridge the differences noted by GAVRILOV. The extraordinary large segment ix in *gatesi* was found in some South African worms and can be regarded as an individual variation. The position of the

spermathecal pores are in one-third BC in typica and *bellavistensis* and in C in *gatesi*, they are big in *gatesi* and minute in the other forms. Variation in the axial level was found in the present investigation and the size of pores varies with fixatives and preservatives and with the condition of the worms. Female pores on xiv anterior to A or AB in typica, behind 13/14 in B in *gatesi* and on anterior margin of xiv in B or AB in *bellavistensis*. The specimens in the present investigations agree with *bellavistensis* in this character as well as having minute, diffuse pores. The differences are so small as to be regarded as individual when not referable to writing the same thing in different ways. The shape of the prostatic porophores varies more in the present material than that described for the three forms by GAVRILOV. The differences in clitellar extension between the different forms is nullified by the present material. Seminal grooves have occasionally been absent in my material so the absence of these in *gatesi* cannot be a distinguishing feature. The thickness of the gizzard is of a quantitative nature that cannot be compared between different accounts and there seems to be very little discrepancy between the different forms. Intestinal origin is in xii or xiii in both JAMIESON's (1967) and my material, it can thus not be used as a distinguishing character. The nephridia are small in *gatesi* and big in *bellavistensis* and in JAMIESON's material. Unfortunately, it is not clear from any of the authors in which segment the nephrida should be small or large, in the present material they are small in v—xii and big from xii onwards. JAMIESON (l.c.) is of the opinion that the size varies with environmental condition but in the present material no variation was found in specimens from different localities. 5/6—8/9 thickened, 9/10—11/12 less so in typica; 6/7—8/9 in *gatesi*; 6/7—8/9 thickened, 9/10—10/11 less and 11/12 still less so in *bellavistensis*. JAMIESON's and the present material bridge the difference in this character. Seminal vesicles in xi in typica and in ix, xi in the other two varieties. JAMIESON found specimens with seminal vesicles in ix or in ix, xi and in the present material they were restricted to xi which indicates that the number of vesicles cannot be used for definition of taxa in this species. There seems to be no reason left to retain these three taxa within *saltensis*.

2.6. Species to be deleted from the South African list

2.6.1. Lumbricidae

2.6.1.1. *Lumbricus terrestris* L. 1758

Lumbricus infelix KINBERG 1866: 98—99
Lumbricus infelix, L. *terrestris*, MICHAELSEN 1899b: 421

Remarks: The type locality for *infelix* was said to be Port Natal (= Durban) by KINBERG; MICHAELSEN (1899b) reexamined the type and found it to be a synonym of *L. terrestris*. There has always been doubt about the authenticity of this record. The locality was question-marked on the original label. So much collecting has now

been done in and around Durban that it must be concluded that the record is erronous. If present, the species ought to have been found in collections from the Cape Town area but this is not the case, which makes the presence of this species in South Africa very unlikely. BEDDARD's (1885) record of a worm "presenting no marked differences" from *L. terrestris* from the E. Cape seems also suspect.

2.6.2. Megascolecidae

2.6.2.1. *Pheretima javanica* (KINBERG) 1866

Megascolex capensis HORST 1883: 195 (Type locality, Cape of Good Hope)
Pheretima quadragenaria, MICHAELSEN 1913c: 535

Remarks: *M. capensis* and *P. quadragenaria* are both synonyms of *P. javanica*. This peregrine species is widely distributed in the Indian Ocean from Indonesia to Polynesia. The only record outside that range is from Cape of Good Hope. It is likely that the types came from some other place than South Africa, a common practise in those days was to write Cape of Good Hope as "Cape" and many species described during that epoque as "cappensis" were actually collected at some other Cape. Considering this, and that the record is far outside the range of the species and that it has never been found since in South Africa it is excluded from the South African list.

3. Discussion

3.1. History of the introduction of earthworms into South Africa.

Preeuropean trade with South Africa has existed for a very long time but data are lacking.

The Phoenicians are said to have circumnavigated Africa and spent one winter growing food crops in the southern hemisphere in around 600 B.C. Proofs of this voyage is, however, very slight.

The Javanese traded with the east coast, at least down to Natal, and with Zimbabwe from about A.D. 400 or 500 (SEDDON 1968; TANDBERG 1968). They had reached Madagascar in the third century A.D. They imported several plants, e.g. bananas, to the east coast.

Extensive trade between South Africa and other continents can be said to have started around A.D. 800 when Arab and Persian traders went down the east coast and established bases at several places, the southern most probably being at Sofala (established about A.D. 900) (MATTHEW 1963). They brought in vegetables and established gardens around their settlements. Extensive trade existed between Kilwa and the Zimbabwean gold-fields via Sofala from about 900 to the arrival of the Portuguese. No records, however, exist that the Arabs introduced any plants or vegetables in the interior of southern Afrika.

Table 20 History of the introduced earthworms

Species	Earliest discovery	Earliest possibly introduction in A.D.	by	Original home	Remarks
Allolobophora caliginosa[2])	1911	1505	Europeans	Europe[1])	
A. trapezoides[2])	1853	1505	Europeans	Europe[1])	
Bimastos eiseni[2])	1925	1505	Europeans	Europe[1])	
B. parvus[2])	1898 or earlier	1505	Europeans	? Europe[1]) ? N America	? via Europe
Dendrobaena rubida[2])	1872	1505	Europeans	Europe[1])	
Dichogaster bolaui[3])	1911	1505	Europeans	W Africa	
D. saliens[3])	1911	1505	Europeans	W Africa	
Eisenia foetida[2])	1872	1505	Europeans	Europe[1])	
E. hortensis[2])	1898 or earlier	1505	Europeans	Europe[1])	
E. rosea[2])	1911	1505	Europeans	Europe[1])	
Eiseniella tetraedra[2])	1898 or earlier	1505	Europeans	Europe[1])	
Eukerria saltensis	1911	1505	Europeans	S America ?	not directly
Lumbricus rubellus[2])	1904	1505	Europeans	Europe[1])	
Microscolex dubius	1898 or earlier	1505	Europeans	S America	? via Europe
M. phosphoreus	1850—1860	1505	Europeans	S America	? via Europe
Octolasion tyrtaeum[2])	1872	1505	Europeans	Europe[1])	
Pontoscolex corethrurus	1911	1505	Europeans	S America	? via SE Asia
Pheretima diffringens[4])	1911	4—500	Indonesians	SE Asia ? China	
P. hawayana[4])	1967	4—500	Indonesians	SE Asia ? China	
P. minima[4])	1967	4—500	Indonesians	SE Asia ? Indonesia	
P. morrisi[4])	1967	4—500	Indonesians	SE Asia ? China	
P. rodericensis[4])	1926	4—500	Indonesians	SE Asia ? China	
P. californica[4])	1927	4—500	Indonesians	? China	

1) or from adjacent parts of Asia
2) Some of these species possibly introduced by Arabs in 800—1200
3) Possibly introduced by Africans in 800—900
4) Possibly also introduced by Indians and Arabs in 800—1200 and Chinese in 1200—1500

Another line of trade existed between the Chola (SE India) and the east coast in about 800—1200. A less developed one was between the east coast and Annam, Burma and south-east China during the same period (MATTHEW l.c.) but this trade was mainly going through Muslim-Indian middle-men.

By 1200 a very extensive trade existed between the east coast and Arabia, Persia, India, south-east Asia and Indonesia. Transcontinental routes from Kilwa to West Africa also seem to have existed as well as several routes to the interior of southern Africa. Big towns had grown up along the coast south to Sofala (FREEMAN-GREENVILLE 1962) and trade posts existed in Natal. Excavations in Transvaal indicates that Indonesians had a highly developed trade with the Mapungubwe culture via Madagascar from around 900 but the results have been censured by the South African government.

Chinese trade with the east coast started in about 1400 but soon declined and were never of any importance (WHEATLEY 1964).

European trade started in 1505 when the Portuguese established a fort at Sofala. For the next century the trade declined through the slaughter of Arabs by the Portuguese and the latters failure in opening trade with the Africans. A new era began in 1652 when the Dutch settlement at Table Bay was inaugurated. Farming commenced and European crops and vegetables was introduced. The Dutchmen remained at the coast till about 1815 but then began to expand northward.

The staple-food for the Africans was introduced during the first millenium A.D. Banana and yams between 1000 and 1500 years ago, maize, cassawa and sweet potatoes during the 16th and 17th century (SEDDON 1968). Farming began in the Transvaal and the Free State in around 800—900 (C^{14} dates, SEDDON 1968).

From the 1850's imported Indian slaves started gardens in Natal with vegetables and ornamental plants brought from (? southern) India. Sugar cane was introduced from Mauritius in 1852, but in what way is unknown to me. Forest plantation started in the 1880's (GRUT 1965) with introduced Eucalyptus, Acacias and Pines from Queensland, Central America, California, the Canary Islands and S. Europe but apparently only as seeds.

Of the twenty-three exotic earthworms recorded (Table 20) ten (or eleven) are of European, six of South East Asian, four of South American, two of West African and one possibly of North American origin. It is of course not certain that a species have been introduced from its original home directly to South Africa but might have arrived via another continent. That peregrine earthworms have been spread throughout the world for centuries is indicated by the mention of phosphorescent earthworms in Europe in 17th century literature. This phosphorescent worm could not possibly have been anything but the South American *Microscolex phosphoreus*. The earliest collections of earthworms, e.g. that obtained by the Eugenia in 1852—53,

brought back almost only peregrine species which were exotic for the region they were collected in.

It seems most likely that the earthworms were introduced with ballast and with vegetables and ornamental plants which were brought to South Africa in crates or pots containing soil. LINDROTH (1957) has shown the importance of ballast in introduction of exotic species. GATES has recorded numerous instances of interceptions of earthworms from this source arriving in the U.S. by ships or aeroplanes. Food crops and trees were apparently always introduced as seeds and could then have had no influence on the introduction of earthworms.

We know that plants and soil have been introduced from Indonesia since A.D. 400—500 and from Arabia, southern India and south-east Asia since 800—1200. It seems very unlikely that this extensive trade should not have been responsible for the introduction of earthworms at their various settlements. The Pheretimas, or at least some of them, would have been introduced at this time. Lumbricids could have been introduced by Arabs but it seems unlikely as they came from the Hadramaut and the Persion Gulf and since lumbricids are virtually absent in those regions as well as along the east coast. Possibly the lumbricids have failed to establish themselves there because of climatic reasons.

Species of South American origin — *Eukerria saltensis*, *Microscolex dubius*, *M. phosphoreus* and *Pontoscolex corethrurus* — must have been introduced by Europeans some time after A.D. 1500 but probably via Europe (*Microscolex*) and South-East Asia or Mauritius (*P. corethrurus*) since trade between South Africa and South America have been very slight. The West African *Dichogaster* might have been introduced, through the west coast trade, by Europeans some time after 1500 but it cannot be excluded that they were brought to South Africa by Africans in their intercontinental migrations and trade. It seems likely that *Nemertodrilus kellneri* MICHAELSEN 1910, only known from Blomfontein and Namibia, was introduced to South Africa either by Africans or by Europeans. Survival in the new home is enhanced by man's habit to settle in areas with the most similar climate to his former home (COON 1965).

Spread within the subcontinent has probably also been advanced by man through the carriage of worms or their cocoons in the soil around roots of plants and by the liberation of unused bait by anglers. Earthworm farms are known from several places in South Africa and Malawi. In at least one case the worms (*E. foetida*, T10) were brought from the U.S.

3.2. Distribution

The main factor affecting the distribution of earthworms is the climate. South Africa has a very variable climate ranging from the cold deserts in the west over the arid and semiarid interior plateau to the hot humid strips on the southern and eastern

coast and with a subtropical climate in the extreme northeastern Transvaal. The following regions (Fig. 12) are recognized by SCHULZE (1965).

Region M (Mediterranean). Average annual rainfall 250—3000 mm varying according to topography. Average daily temperature minima 15° C (January) and 6 °C (July), extreme — 5 °C, frost rare.

Region A (Southern coastal strip). Warm, humid. Rainfall 400—1600 mm evenly distributed throughout the year. Temperature minima 15 °C and 7 °C, extreme — 4 °C frost practically unknown.

Regions Se and E (south-eastern and eastern coastal strip). Warm, humid. Very similar to A but with summer-rain 500—1250 mm frost in the interior valleys for 30—40 days.

Region D (Dragensberg). As E but greater temperature fluctuation due to high altitude. Frost 90—150 days depending on altitude.

Region L (Lowveld). Rather warm, humid. Rainfall 500 in the north to 700 mm in the south with certain high altitude spots receiving 2000 mm, in November—March. Temperature minima 18 °C and 8 °C (extreme — 2 °C), frost rare.

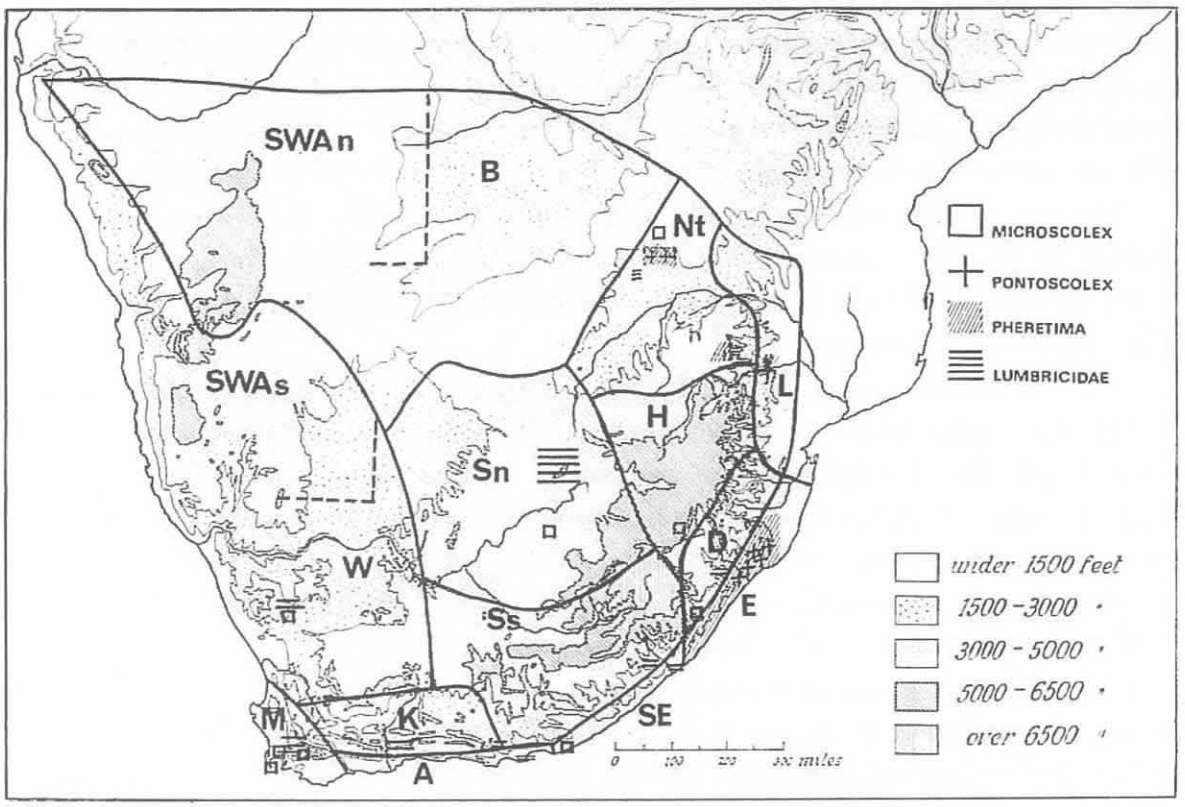

Fig. 12. Climatological regions and distribution of terrestrial earthworms in South Africa. Explanations in the text.

a clay soil and that this species was very susceptible to desiccation (cf. GRANT 1955a for *P. hupeiensis*).

Nothing is known about temperature and moisture tolerance in *Pontoscolex*. A single specimen of this species was found in diapause in a completely dried field (soiled cracked), the densest populations have been at river banks in soils having a moisture level over the water-logging point. Judging from field data from South Africa, Malawi and Uganda the optimum would be in water-logged soil. The distribution pattern indicates also a high temperature optimum.

The lumbricids are comparitively resistant to desiccation and can withstand frost for long periods. Optimal soil temperature and moisture levels are below those of *Pheretima* (GRANT 1955a, b: KHALAF EL-DUWEINI and GHABBOUR 1965, 1968) which, at least in part, explains their near absence from the warmer regions of South Africa.

Pedological factors probably have a very little influence on the distribution, the low organic matter content of agricultural soils in the Free State and the Transvaal might be a contributing factor for the total absence of earthworms there.

3.3. Earthworm association, competition and extermination

Extermination of endemic earthworms have for the past half century been blamed on competition with more "advanced", introduced forms without demonstrating the existence of competition among earthworms. Competition can be presumed to exist for food among species occupying the same ecological niche. This is seldom the case with introduced and endemic earthworms in South Africa.

In the present survey earthworms were collected in 128 localities of which 27 represent more or less natural habitats while the other 101 come from cultural habitats. Endemic microchaetoids were found in 42 localities including four of the oligoporeutic *Tritogenia grisea*, endemic acanthodrilines in five localities and exotic species in 85 localities of which *Microscolex* occurred in one, *Dichogaster* in one, *Pontoscolex* in 18, lumbricids in 23, *Pheretima* in 45 and *Eukerria* in 21 localities. Endemic and exotic species were found together in 35 localities (Table 21) of which three were "natural" habitats. In the other 24 "natural" localities only endemic species occurred. They were dominant in the three "natural" ones in which they were found associated with exotics while the exotics were dominant in the cultural localities. Of the 101 cultural localities exotic species only were found in 69, exotic plus oligoporetuous endemics (*Tritogenia grisea*, *Geogenia modesta*, *G. timmiana* and *Udeina wahlbergi*) in nine, exotics plus other endemics in 20 and endemics only in three localities.

The most common associations are between microchaetoids and *Pheretima* and/or *Pontoscolex*. *Tritogenia grisea* has been found together with lumbricids (three times), *Pheretima* (twice) and *Dichogaster bolaui* (once). Endemic acanthodrilines have only

Table 21 Earthworm associations found in the present survey[1])

Association	Number of localities	Habitat
A. trapezoides — E. rosea	2	Garden and grass field (Kikuyu)
A. trapezoides — P. diffringens	3	Gardens (2). Pasture (1) (A. dominant in garden, P. in pasture)
A. trapezoides — P. diffringens — P. morrisi — P. hawayana	1	Lawn
A. trapezoides — G. algoensis	1	Garden
A. trapezoides — D. rubida	1	Garden
A. trapezoides — P. diffringens — P. minima — Udeina	1	Grass field, riverbank
E. rosea — T. grisea	2	Lawn, Eucalyptus plantation
E. rosea — P. diffringens	1	Arable land, in a town
E. rosea—Geogenia	1	Grass field (arable)
O. tyrtaeum — P. ?hawayana	1	Plant pot
P. diffringens — Po. corethrurus	2	Grass field at riverbank
P. diffringens — P. rodericensis — Po. corethrurus	1	Grass field at riverbank
P. diffringens — P. rodericensis — P. hawayana — Po. corethrurus	1	Sugar cane field
P. diffringens — P. minima — P. rodericensis	2	Lawn
P. diffringens — P. rodericensis	1	Grass field (cultural)
P. diffringens — Geogenia	5	Grass fields
P. diffringens — T. grisea	2	Grass at riverbank
P. rodericensis — hawayana	1	Grass field (pasture)
P. rodericensis — P. minima	1	Sugar cane field
P. rodericensis — Po. corethrurus	1	Lawn
P. rodericensis — Geogenia	1	Grass field (natural)
P. sp. — Geogenia	2	Grass field (natural)
P. corethrurus—Geogenia	2	Grass field at riverbank (natural)
Microscolex dubius — M. decipiens	1	Thorn-bush savanna
T. grisea — D. bolaui	1	?

1) Dominant species printed in italics.

once been found together with exotics (N40) and at one more time with a microchaetoid. Among the exotics the most common association was *Pheretima diffringens* and one or more other species of *Pheretima* and/or *Pontoscolex corethrurus* in sugar cane fields or on adjacent grass fields.

In which cases can competition be expected? *Eiseniella tetraedra* and *Eukerria saltensis* can be excluded as they are amphibious and occupy another habitat than the terrestrial earthworms. Among the terrestrial earthworms competition is unlikely between *Microchaetus* and *Geogenia* and the exotics since the former are burrowers

while the latter are top-soil forms. The field-notes indicates that there are also differences in their microdistribution: N3 *Pontoscolex* at riverbank in very wet soil, microchaetoids further up in rather dry soil. N12 *Pheretima* in sugar cane field among the reeds, *Pontoscolex* a few feet off the edge in grass. N39 *Pheretima* at the water's edge (of river), microchaetoids further up the slope. N42 *Pheretima* along at the water's edge of a small stream, microchaetoids among the reeds several metres away from the stream. C20 *Pheretima* in riverbed, microchaetoids in wet area further up the slope.

In Malawi *Pontoscolex corethrurus* was found together with *Pareudrilus nyassaensis*, *Pygmaeodrilus* (new) sp. and *Gordiodrilus* (new) sp. in one locality and with *Stuhlmannia* v. *variabilis* and *Alma* sp. in one locality in Uganda. Both localities were off the edge of a town (Zomba, Jinja) and in neither were any species dominant; soil factors seemed optimal and in Zomba big populations were found of all species. In association with *Iritogenia grisea* competition can be expected as this species as well as those found with it are top-soil species and they have been collected in localities with very little nutritient availably.

The picture emerging is not that of exotics competing out the endemics but that of endemics occurring in natural habitats and exotics in cultural lands while they meet on the border areas without exterminating each other. The absence of endemics must be due to some other reason, the most likely being the enormous environmental changes and the shockingly advanced destruction of natural habitats.

Although man has been present in South Africa for a few hundred thousand years, pre-european change of the environment has been slight (Acocks 1953; Meredith and Rose 1955). Since the invasion of the Europeans over 97% of the indigenous forests have been destroyed and only remnants are now left of a forest belt extending along the whole southeastern and eastern coast north to the Zimbabwean border (Acocks 1953; Palmer and Pitman 1961). Indigenous forest now occupies approximately 0.02% of South Africa while plantation of exotic trees raise the figure for forests to 1% (Department of Forestry 1964; Grut 1965). Early travellers and naturalists reported on the "grass-land paradise" of the Orange Free State and the Transvaal (Meredith and Rose 1953); this area is now steppe or near desert. The desertoid Karroo has been created by man and has now invaded all of the interior plateau except the northeastern Transvaal. In 1950 50% of South Africa was either desert or below the critical stage of becoming desert while another 20% were in danger of becoming desert if drastic measures were not implemented immediately (Acocks l.c.) since 1950 the situation have become worse and very little have been done to stop the deterioration.

The destruction of indigenous forests and grasslands and the replacement with exotic trees and crops have left the soil unprotected from wind and rain with the result that the soil dries out, winds and dust-storms remove the humus and mineral

layers, the precipitation washing away the top-soil and the loss of water by the soil as the water storage capacity has been removed. Organic matter content of the soils on the plateau is usually only a fraction of a percent compared to 5—7 % in similar East African soils. Many meterologists also claims that the precipitation decreases after the removal of forests.

The effect on the soil fauna have been disastrous, no macroinvertebrates are present for hundred of square miles in the Free State and the Transvaal, even along the Natal coast no earthworms were found in the plantations of exotic trees.

The water-courses are heavily polluted, industries letting out their wastes without any clearing directly into the rivers. Endemic ocnerodrilids have here been replaced by *Eiseniella tetraedra*, *Dendrobaena rubida* (both species also found in sewage filters) and *Eukerria saltensis*.

The endemic acanthrodrilines are sylvan and have certainly been exterminated wherever the indigenous forests have been destroyed. The western border of the microchaetoids has probably been pushed a considerable distance to the east as the desert and Karro have advanced.

Changes of the earthworm fauna in Natal is indicated by the fact that MICHAELSEN (1913e) in 1911 collected earthworms from nine localities yielding four species of acanthodrilines while in the present survey earthworms were obtained from 43 localities but only one acanthodriline were found. A comparison of the earthworms from Howick collected by MICHAELSEN in 1911 and in the present survey (1967) shows the following:

1911 (MICHAELSEN 1913e)	1967 (Present investigation)
Udeina warreni	*Udeina* sp.
Tritogenia howickiana	*Haplotaxis* sp.
Geogenia caementerii	*Pheretima minima*
Pheretima diffringens	*Pheretima diffringens*
Eukerria saltensis	*Eukerria saltensis*
Allolobophora trapezoides	*Allolobophora trapezoides*
Dendrobaena rubida	*Eiseniella tetraedra*

Seven species were found at both occasions, in 1911 there were three endemics and four exotics while in 1967 there were two endemics and five exotics of which *Haplotaxis* certainly were present in 1911. *Udeina* sp. is possibly *U. warreni* but only a single, juvenile specimen were obtained. In approximately 50 jears two endemis and one exotic seems to have disappeared from this locality, the most likely reason for their disappearance is that they were not adapted to the pollutants of the river draining the area (all species were collected at the foot of the Umgeni falls).

Peregrine earthworms are resistant to many biocides, such as DDT and BHC while it can be suspected that endemic species are suspectible. It is not known

whether biocides have any long-term effect on the reproductive rate in earthworms as they have on birds (WURSTER 1969) but some biocides are cancerogenous to earthworms (ASPÖCK and AN DER LAN 1963).

Very little data are available from other continents. MICHAELSEN (1925) describes how, in a Mexican garden, peregrine species were abundant as long as the garden were well kept but, when the garden was abandoned, the peregrine species were replaced by an endemic acanthodriline.

LEE's (1961) description of the interaction between endemic and introduced species is very similar to that given here. New Zealand has 170 species of which 21 are introduced. The endemics occurring under natural vegetation and introduced species occurring in gardens and agricultural soil. When the indigenous vegetation have been removed the endemic earthworms have disappeared and later been replaced by introduced forms. He concludes that there is no competition between endemic and introduced forms.

3.4. The causes for success of peregrine species

Nearly 100 species of earthworms are more or less peregrine. They represent all families of earthworms but the largest number of species have been provided by the Lumbricidae and Megascolecidae (*Pheretima*). Some species, e.g. *Eudrilus eugeniae*, have been more successful on other continents than on their own while most have a very wide distribution in their original home.

The reason for the success of the peregrine species was attributed by MICHAELSEN (1903b) to their small size (under 200 mm), their occurrence in gardens and their phylogenetic advancement and superiority. The size seems to be less important than MICHAELSEN supposed, their phylogenetic superiority over endemic species has still to be demonstrated.

The most important factors influencing the introduction of earthworms now seems to be a great adaptability to new environments and a parthenogenetic mode of reproduction. Only those species adapted to a life in arable land, gardens and green-houses would be brought with plants to other areas. They must be able to survive the adverse condition during the transport. Many of the peregrine species can survive in very dry soils, the lumbricids and *P. corethrurus* go into diapause as a protection against desiccation when the moisture level becomes to low.

When arriving in a new environment parthenogenesis is a clear advantage as a worm do not have to find a mate to reproduce. Of the 23 introduced species in South Africa 13 are parthenogenetic, in four species (*A. caliginosa*, *D. bolaui*, *D. cravi* and *M. phosphoreus*) the mode of reproduction is unknown but in at least some of them parthenogenesis can be suspected, three (*P. hawayana*, *P. morrisi* and *P. rodericensis*) are probably and two (*E. foetida* and *L. rubellus*) are certainly biparental. The only really widespread endemic species (*T. grisea*) is also parthenogenetic.

Similar conditions are present in other areas. Mauritius with eight species (all introduced) have five parthenogenetic, two suspected and one known biparental species (LJUNGSTRÖM, unpublished). Of the 25 species introduced to Brazil (MICHAELSEN 1927; RIGHI and KNEPPER 1965; RIGHI 1968) four are biparental, eleven parthenogenetic and ten suspected parthenogenetic or with unknown reproduction. Of the 18 species of *Pheretima* known from the Americas (GATES 1958c and 1961) ten are, or are suspected to be parthenogenetic. All parthenogenetic species are either oligoporeutic or peregrine.

The peregrine species have not only been introduced into more places than biparental ones, they show also a much wider distribution in the new area. The parthenogenetic *P. diffringens* have been found in practically all places in South Africa where Pheretimas occur while the presumed biparental species have been found in much fewer localities. The parthenogenetic *E. rosea* and *A. trapezoides* are the most widespread species in the interior of South Africa while the biparental *E. foetida* was found at four and the biparental *L. rubellus* at one locality.

So far only genital polymorphism have been studied to any extent but data on the variation of certain somatic systems suggest that they vary according to environmental factors. A red pigment is characteristic for sylvan, top-soil species, e.g. South African acanthodrilines. Burrowing species, e.g. *Geogenia* and *Microchaetus* are usually dark grey above fading to light grey on the ventrum. Cryptic coloration seems to be a protection against predators. Dorsal pores have been considered an adaption to dry soils (STEPHENSON 1930); they are present in the lumbricids and Pheretimas but absent in *Pontoscolex* and in the South African endemics. These pores seem to begin further forward in South African *A. trapezoides* from dry than from wet soils. On the other hand *Pontoscolex* have been found in drier soils than *Pheretima* but this might be due to the former's ability to go into diapause. Diapause (also and adaptation against desiccation) is also present among the microchaetoids and during the dry period these worms migrate down to the ground-water table (LJUNGSTRÖM, unpublished) as has also been demonstrated experimentally by REINECKE (pers. communication).

The typhlosole is an adaptation to soils poor in nutrients. It is well developed in the introduced lumbricids, Pheretimas and especially in the endemic microchaetoids but absent in the acanthodrilines.

Theoretically, a peregrine earthworm should have a high reproductive capacity, be parthenogenetic, physiologically adapted to dry, poor, bare soils, biocides and artificial fertilizers.

4. Summary and conclusion

1. Of the about 170 species of earthworms known from South Africa 23 are introduced, one more (*Nemertodrilus kellneri*) is suspected to have been introduced. The Lumbricidae, Megascolecidae, Octochaetinae and probably the Eudrilidae are only represented by introduced species while the Glossoscolecidae, Ocnerodrilidae and Acanthodrilinae are represented by both endemic and introduced forms.

2. Great variation was found in the morphology of *Allolobophora trapezoides* and *Eisenia rosea*. It is concluded that several parthenogenetic morphs of *E. rosea* have evolved after its arrival in South Africa. The anterior position of dorsal pores in some populations of *A. trapezoides* is suspected to be an adaptation to dry soils. Variation in other species could not be correlated with ecology or distribution and must be regarded as individual variation.

3. Pheretimas might have been introduced to South Africa by Indonesians in A.D. 4—500, other species were probably introduced by Europeans after 1505. Earthworms, especially the Pheretimas, could also have been introduced in 800—1200 by Indians and Arabs and in 1200 to 1500 by Chinese. *Dichogaster* and *Nemertodrilus* might have been brought to South Africa in 800—900 by Africans. Ten (or eleven) species are of European, five of Southeast Asian, four of South American, two of West African and one possibly of North American (or European) origin. The South American species have probably been introduced via another continent, *Microscolex* via Europe, *Pontoscolex* via Southeast Asia or Mauritius and *Eukerria* not known. Earthworms must have been introduced with the dumping of ballast and with ornamental plants or vegetables brought to South Africa in crates or pots containing soil, as trees and crops probably always have been introduced as seeds. Spread within South Africa has occurred in the same manner and in addition by liberation of unused bait by anglers and the spread of cocoons by streams and rivers (*Eiseniella*, *Eukerria*).

4. The distribution of introduced species can be correlated with climate (temperature, precipitation) and the geographical origin of the species. The temperate lumbricids and *Microscolex* occur in the colder, interior regions of South Africa, while the tropical Pheretimas and *Pontoscolex* occur in the mild, coastal and northeastern parts of the country. The amphibic (limnic) *Eiseniella* and *Eukerria* are intermediate in occurring in all climatic regions but the temperate *Eiseniella* mainly in the interior and *Eukerria* mainly along the east coast. The difference in distribution is explained by the temperate species' higher resistance to frost, low temperatures and low soil moisture content.

5. The introduced species are restricted to cultural habitats while the endemic species to natural ones with some overlapping of endemic and introduced forms in border regions. Exterminations of endemic species is due to a change of the habitat brought about by the Europeans. The near extinction of indigenous forests has caused the extinction of many acanthodrilines and a general desertification and lowering of the ground-water table have, at least, limited the distribution of microchaetoids. It is no longer possibly to reconstruct the distribution of endemic earthworms as they have now become extint over large areas. Endemic species have not been exterminated in competition with introduced forms. Competition is unlikely as the two groups occur in different habitats or, when meeting, they have a different microdistribution and behaviour (introduced forms in the top-soil, endemics burrowers).

6. The peregrine earthworms are characterized by often reproducing parthenogenetically, a great morphological (and genetical) variability and physiological adaptation to dry, poor soils while these characteristics are usually absent in endemic species.

5. Zusammenfassung

Nach Südafrika eingeschleppte Regenwürmer. Über ihre Systematik, Verbreitung, die Geschichte der Einschleppung und die Ausrottung endemischer Regenwürmer

Von den etwa 170 aus Südafrika bekannten Regenwürmern wurden 23 (oder 24) Arten aus sechs (oder 7) Familien eingeschleppt. Bei *Allolobophora trapezoides* und *Eisenia rosea* wurde starker Geschlechtsdimorphismus festgestellt. Die Morphen des letzteren haben sich alle erst nach der Einschleppung in Südafrika entwickelt. *Pheretima*-Arten könnten um 400 bis 500 nach der Zeitwende von Indonesiern eingeschleppt worden sein, während die meisten Arten nach 1505 durch Europäer eingeschleppt wurden, obwohl das auch durch Afrikaner (800—900), Inder und Araber (800—1200) und Chinesen (1200—1400) erfolgt sein kann. Die Verbreitung entspricht der geographischen Herkunft der Arten und dem Klima; die Vertreter gemäßigter Gebiete kommen im Innern, die tropischen Arten längs der Ostküste und in Nordost-Transvaal vor. Die endemischen Regenwürmer wurden und werden durch vom Menschen hervorgerufene Umweltveränderungen ausgerottet: Acanthodrilen durch Zerstörung der ursprünglichen Wälder, Microchaetinen durch Grundwassersenkung und Verwüstung der Savannen. Beweise für eine Konkurrenz zwischen endemischen und eingeschleppten Arten konnten nicht gefunden werden. Die fremden Regenwürmer sind oft durch parthenogenetische Vermehrung, große morphologische (und genetische) Variabilität und physiologische Anpassung an trockene, arme Böden ausgezeichnet, während den endemischen Arten diese Eigenschaften gewöhnlich fehlen.

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